Markus Böckelmann and Wolfgang Lücke, Göttingen, and Reinald-Jörg Weimar, Soest

# Evaluation of Convection Dryers

## Requirements and Possibilities

*Grain drying is a proven method which allows kernel quality and storage stability to be secured. The intention of farmers is to keep specific drying costs as low as possible. In addition, secondary effects, such as $CO_2$ reduction, kernel protection, and quality maintenance are gaining in importance.*
*The question of how kernel-specific drying energy demand and dryer-specific efficiency can be determined and how different dryers or drying systems must be evaluated in process-technological comparison still remains to be answered. Therefore, studies are being carried out in order to find out whether dryers or drying processes can be described with the aid of parameters.*

Dipl.-Ing. Markus Böckelmann is a scientist working in the Section of Agricultural Engineering (director: Prof. Dr. sc. agr. Wolfgang Lücke) of the Department of Crop Science of Georg-August University Göttingen, Gutenbergstr. 33, D-37070 Göttingen; e-mail: *M.Boeckelmann@t-online.de*.
Prof. Dr.-Ing. Reinald-Jörg Weimar works at the Institute of Technology- and Knowledge Transfer in Soest County – Institute of the College Department Soest, Lübecker Ring 2, D-59494 Soest.

**Keywords**

Hot air drying, drying capacity, energy demand

In practice, the drying of grain and in particular grain maize is considered one single technique. However, the processes in the product and during the process are variable. Drying is mainly characterized by three factors:
1) The design and the working principle of the drying system
2) Manual dryer setting or control conditions in automatically controlled systems
3) Product-specific properties of the cereals to be dried

Drying propensity as a term for the description of the product-specific drying characteristics is not defined in physics and process technology. However, the term as such is known. Here, two different levels of consideration are relevant:
a) The drying propensity of the cereals in combination with the process technology used for drying. Here, it is important how well the design and the process technology of the drying system used allow it to exploit the water evaporation capacity or the water evaporation requirements of the cereals.
b) The drying propensity of the cereals as a direct, product-specific characteristic value.

### Specific Drying Energy Requirements

According to the current state of the art, evaluation in practical use during grain maize or cereal drying only includes drying capacity and specific drying energy requirements. In practice, specific drying energy requirements can be based on two different values:
1) Specific drying energy requirements in kWh per kg of evaporated water
2) Specific drying energy requirements in kWh per 1,000 kg of wet material and per percent of water content reduction

Different systems can be compared by determining an idealized water content reduction. Approaches 1) and 2) are both common in practice for the evaluation of specific drying energy requirements. However, these approaches only allow dryers to be roughly compared as to whether the drying process is biologically and economically sound. Especially agricultural dryers for cereal- or grain maize drying are only used to a limited extent. This result(ed) in the current requirement profile based on the following ranking:
• dryer capacity
• operator friendliness
• drying energy requirements

Due to the increasing expenses for drying

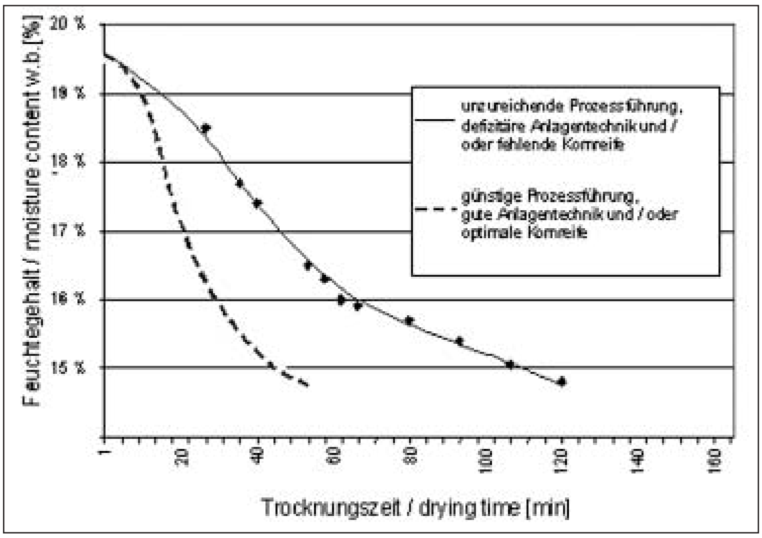


*Fig. 1: Influence of dryer technology, process control, and cereal properties on the drying duration required by different continuous flow dryers (The dots mark different continuous flow dryers).*

energy, the requirement profile for agricultural dryers is currently changing. The shift towards a virtually even weighting of the three main criteria, which is being called for by farmers, can only be realized based on the complete optimization of the entire process. However, this is only possible if the product-specific drying energy requirements are evaluated separately from the total drying energy requirements of the dryer.

Practical experience shows that this value can be up to twice as high in actual operation as compared with the theoretical drying energy requirements of mere water evaporation. The main factors responsible for this difference are the kind of water binding and water distribution within the kernel.

Additional factors are technical dryer characteristics, such as unfavourable air- and heat distribution in the dryer, unadapted drying times, inappropriate heat- and air supply, or wrong constructive dimensioning of those dryer units which determine capacity [1].

### Comparability of Dryers with the Aid of Parameters

Studies carried out by the authors showed a relevant range of product-dependent drying energy requirements. These must be considered as a function of variety, senescence, vegetation- and weather conditions (locational factors), and grain structure regardless of the concrete dryer. Drying technology also influences the drying energy requirements. The decisive question is whether a dryer allows the water evaporation potential of the cereals to be exploited to the greatest possible extent. Here, a distinction must be made between maximizing drying throughput and keeping energy use during drying to a minimum [2].

Drying tests carried out by the Section of Agricultural Engineering of the Department of Crop Science of the University of Göttingen showed that the optimization of the drying speed requires a command of process technology with regard to the drying propensity of the cereals. This applies equally to grain- and maize drying.

Under aspects which are not exact from a physical and a scientific viewpoint, drying propensity describes the ability of cereals to give off the moisture in their interior and on their surface until a certain final moisture content is reached with the aid of the dryer if dryer configuration is optimal. Even though the results of drying processes of agricultural products can well be entered into energetic balances, differences between the various dryers are significant. Drying propensity is no characteristic individual value which can be directly measured or calculated, such as the friction coefficient μ of material pairs. It must rather be viewed like the Cw value in cars, which serves as a descriptive value of the drag coefficient at a certain relative wind speed in a specific car.

For application by the dryer operator or the design engineer, drying propensity is ultimately interesting with regard to its effect on the dryer and the entire drying process. In a physically oriented description of the drying process, it is therefore possible not to use any product-specific measurement values for practical use, but to de-couple physical measurement values according to the functional principle of dryers and to apply them proportionally.

Thus, practical observations show that products can be dried differently and at different speed. For this reason, a large number of dryer types is available [3]. This raises the question of which dryer has the best characteristics for a certain product. Therefore, it is important that different dryer types can be compared with regard to throughput, specific energy requirements, moisture evaporation, and drying duration while taking quality requirements into consideration.

### Evaluation of different dryers

During project work between 2002 and 2006, a total of 14 different agricultural dryers and a total of 30 drying processes have been measured and evaluated with the aid of parameters. In this contribution, the results can only be outlined in an overview. The result shows that suitable parameters allow the advantages and disadvantages of different dryer designs to be assessed with regard to drying duration, specific drying requirements, and the ratio of drying volume and dryer capacity regardless of size and the cereals to be dried. It is also possible to distinguish differences in the drying technique in dryers whose design is virtually identical. This enables favourable dimensions or operational parameters of dryers to be determined. In addition, the specific capacity ratios of a dryer used for different agricultural products can be classified for process evaluation (*Fig. 1*).

### Conclusions

The consideration of different dryers shows that a goal conflict exists between maximizing capacity and minimizing energy use during drying. Only differentiated measurement for dryer control with the aid of measurable operating conditions allows balances for dryers to be drawn up and reserves as well as potential throughput reserves to be detected. Given increasing energy prices and defined quality parameters, characteristic quantities allow drying processes to be better controlled under technical and economic aspects. Based on the perspectives provided by the available set of data, one can expect that drying-technological parameters can also be used for dryer control.

## Literature


Books are marked by •

[1] *Böckelmann, M.*: Qualitätssicherung durch dokumentierte Trocknung. Mühle+Mischfutter, (2003), H. 23, S. 689 - 691

[2] • *Krischer, O., und W. Kast*: Die wissenschaftlichen Grundlagen der Trocknungstechnik. Springer-Verlag, Berlin – Heidelberg – New York, 1978, ISBN 3-540-08280-8

[3] *Toftdahl, O.*: Grain Drying. Innovation Development Engineering ApS, Denmark, 1987