DLG Test Report 6265 F

Bühler GmbH

Eco Dry STKL6-05/02 continuous-flow dryer

Drying output and energy demand

DLG FOKUS TEST

04/15 Drying output and energy demand

Test Center
Technology and Farm Inputs

www.DLG-Test.de

Overview

The FokusTest is a smaller-scale DLG usability test intended to allow product differentiation and special highlighting of innovations in machinery and technical products used primarily in agriculture, forestry, horticulture, fruit cultivation and viticulture, as well as in landscape and municipal management.

This test focuses on testing a product's individual qualitative criteria, e.g. fatigue strength, performance, or quality of work.

The scope of testing can include criteria from the testing framework of a DLG SignumTest, the DLG's extensive usability test for technical products, and concludes with the publishing of a test report and the awarding of a test mark.

The DLG FokusTest on Dryer Systems describes the quality and suitability testing conducted on a dryer system. Dryer output and energy demand are criteria that provide information about system throughputs and the amount of power required to achieve the specific throughput.

No other criteria were covered by the test.

Assessment – Brief Summary

The continuous-flow dryer test yielded good throughput results and very good results in terms of specific thermal energy demand.

Table 1:
Summary of results

Dryer output		**Score***
Throughput		
Dry product (operating conditions)	2.45 t/h	N/R
Dry product (standard conditions)	2.74 t/h	+
Wet product (operating conditions)	3.30 t/h	N/R
Wet product (standard conditions)	3.57 t/h	+
Kernel moisture decrease	22.3 % (35.2 % down to 12.9 %)	N/R
Water removed from maize kernels	0.84 t/h	N/R
Energy demand		
Energy demand per t of wet product		
– thermal	215.3 kWh/t	+ +
– electrical	10.2 kWh/t	+
Specific energy demand per t of water removed	962 kWh/t (3,464 kJ/kg)	+ +
Air flow rate per t of wet product	~10,000 m³	+

Note
Standard conditions: The product is dried from a 35 % moisture content down to 15 % at ambient conditions of 5 °C, 80 % relative humidity, 1013 mbar. Measurements were taken at a hot-air temperature of 110 °C. The design temperature is 125 °C.

* Bewertungsbereich: + + / + / ○ / – / – – (○ = standard requirement, N/R = no rating available)

The Product

Manufacturer and Applicant

Bühler GmbH
Grain Logistics
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Germany

System under test:
Eco Dry STKL6-05/02
Continuous-flow dryer

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Description and Technical Data

The Eco Dry STKL6-05/02 continuous-flow dryer by Bühler GmbH dries the product in a continuous flow process.

The fresh product passes the drying column from top to bottom. The air enters and exits the product batch through the conical ducts in the column roof. The process begins as heated air enters the batch through a roof duct, heating the product so it releases its moisture into the air flow. After the air absorbed the water and cooled it exits the product batch through an exhaust duct. The air flow is controlled by two fans – a main fan that draws the air through the drying column and a recirculation fan that returns some of the air to the process.

The system under test is equipped with Bühler Eco Dry technology, which cools the product in the bottom section of the drying column. The air used in this process heats up but does not saturate and is returned to the hot-air flow by the recirculation fan. This design increases the system's energy efficiency. The system uses a number of technical features such as a diagonal arrangement of the roofs that are designed to increase the consistency of the drying results.

The exhaust air is treated by a dust extraction system.

The dryer under test was primarily designed for maize drying but, according to the manufacturer, will also handle any other flowable products.

Table 2:
Specifications (manufacturer information)

Product data	
Description	Maize*
Bulk density (wet product)	750 kg/m³
Moisture content on entry	35 %
Moisture content on exit	15 %
Design data	
Hot-air temperature	125 °C
Ambient temperature	10 °C
Ambient humidity	75 % rel. hum.
Performance data	
Wet product throughput	approx. 3.9 t/h
Dry product throughput	approx. 3.0 t/h
Water evaporation capacity	approx. 0.9 t/h
Dryer specifications	
Dryer capacity	25.1 t**
Active dryer capacity	17.9 t**
Dimensions L x W x H	6.8 m x 2.8 m x 10.6 m
Electrical rating (dust extractor included)	36.1 kW

Fans		
Type	Exhaust fan	Recirculation fan
Number	1	1
Drive rating	30 kW	5.5 kW
Maximum fan capacity	40,000 m³/h	12,000 m³/h
Rated exhaust air output	40,000 m³/h	
Air heater		
Type	Gas surface burner	
Fuel	Natural gas	
Heating value	10 kWh/m³ (standard conditions)	
Maximum output	1 x 1.2 MW	
Fire detection system		
Type	Integrated into the dryer controller	
Exhaust air treatment		
Type	AS39 centrifugal separator	

Note

* cleaned, biologically-mature wet product
** at a bulk density of 750 kg/m³

The Method

The dryer test was conducted on a farm in the German district of Donau-Ries from 21 to 25 October 2014. The dryer, which is used to dry a wide range of crops, is powered with natural gas.

This test investigates the drying process for maize.

Favourable weather conditions and a well-timed testing schedule ensured the presence of mature, high-quality maize kernels.

The output of the dryer was measured by weighing the total amount of dried maize kernels with a calibrated belt scale.

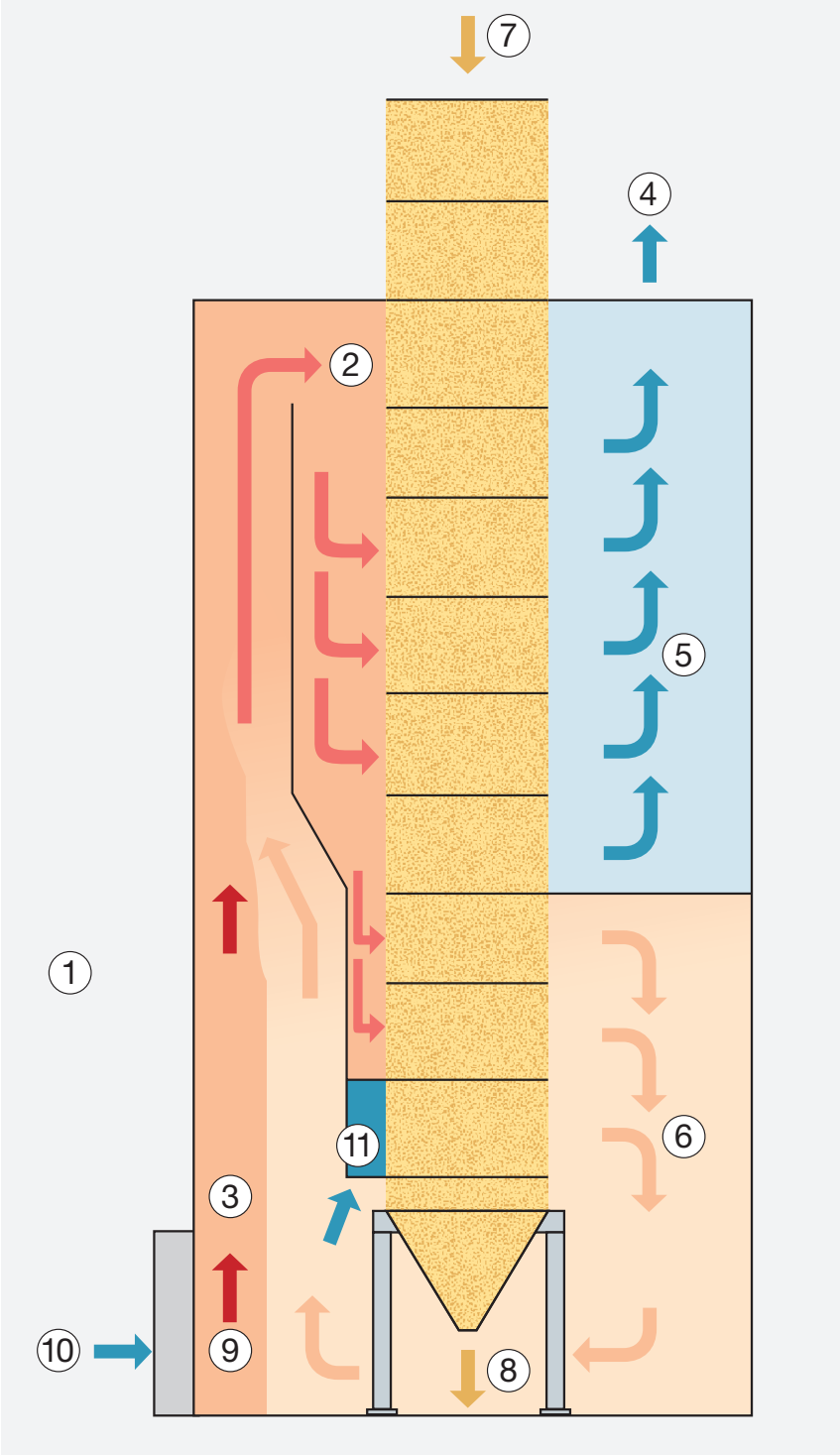

Figure 2:
Dryer diagram

In addition, samples were taken from the fresh and dry product batches to determine the moisture content.

To calculate the dry product throughput ($\dot{m}_{DP}$) the dry product mass (m_{DP}) was divided by the time required for drying (t), see Tables 1 and 3.

$$\dot{m}_{DP} = \frac{m_{DP}}{t}$$

The wet product throughput ($\dot{m}_{WP}$) was calculated from the dry product throughput and the moisture content determined for the dry and wet product batches (F_{DP} and F_{WP}).

$$\dot{m}_{WP} = \dot{m}_{DP} \times \frac{1 - F_{DP}}{1 - F_{WP}}$$

The dryer output values ($\dot{m}_{DP}$ and $\dot{m}_{WP}$) were used to calculate the water removal performance ($\dot{m}_{W}$).

$$\dot{m}_{W} = \dot{m}_{WP} - \dot{m}_{DP}$$

Several gas flow meters were used to determine the thermal energy input.

The relevant air flow rates were determined by differential pressure measurement using the relevant fan performance curve. On request by the client, further air flow rates were added to the measurements.

At a dryer capacity of 25.1t and a throughput of roughly 3t of maize kernels per hour, a typical average dead time of at least eight hours should be allowed for before the system settles at a steady operating level. According to the manufacturer, the dead time may vary depending on the type of dryer system and weather conditions.

Please note that the performance data specified in this report have been adjusted to reflect standard conditions. The analysis cycles were initiated after the dryer had settled out at a steady operating level and took approx. 12 hours. For reasons of clarity this report does not list all test cycles conducted.

Table 3 on page 6 provides a summary of the test results. The figures in dark blue fields reflect measurements, all other figures were derived at by calculation.

System operation

For the entire period of testing the dryer system was constantly operated at overdrying levels. The moisture content levels of the dried maize kernels almost never exceeded 13 %. The thermal energy demand results shown in Table 3 were adjusted to reflect this scenario, but it is assumed that throughput would have been higher.

The dryer is controlled manually as there is no closed-loop system in place to control dryer operation relative to entry or exit moisture levels. According to the manufacturer, closed-loop system control would be possible by using an automatic moisture control system, which was developed specifically for the Eco Dry dryer model range. The entry crop moisture is not captured either. This scenario leads to a situation in which the dryer's full potential is not exploited.

The blend chamber mixes the recirculated air with the heated natural air. The blending temperature is set using the dryer control. The test temperature was set to 110 °C, which is 15 °C below the 125 °C design temperature.

Throughput

The determined dryer throughput was 2.74 t/h of dry product whilst drying a 35 % moisture level to 15 % at an ambient temperature of 5 °C. This set-up required an hourly supply of 3.57 t of fresh maize kernels. This translates into a water removal of 0.84 t/h. If the dryer had been operated according to design, i. e. at a hot-air temperature of 125 °C, the cycle times would have been shorter, hence the throughput per hour would have been higher.

Energy demand

Throughout the test the dryer consumed an average 769 kW of heating power. This means 215.3 kWh of thermal energy were required to dry one tonne of fresh product. Each hour the dryer evaporated 0.84t of water, which translates into an energy demand of 3,464 kJ to evaporate 1kg of water.

In theory, the system has an energy requirement of 2,382 kJ to evaporate 1 kg (approx. 1 L) of water at a kernel temperature of 50 °C and 1,013 mbar of atmospheric pressure. Compared to the efficiency of a convection dryer system the resulting values are at a very good level.

The test revealed an average electrical energy demand of 33.7 kW. Consequently, the total electrical energy required for the drying process amounts to 10.2 kWh per tonne of fresh product. This value is at a good level.

Temperatures inside the dryer

Figure 3 shows samples of temperature development inside the dryer during the test cycle run from 4 p.m. to 3 a.m. As the operating point is very stable, the temperatures vary very little.

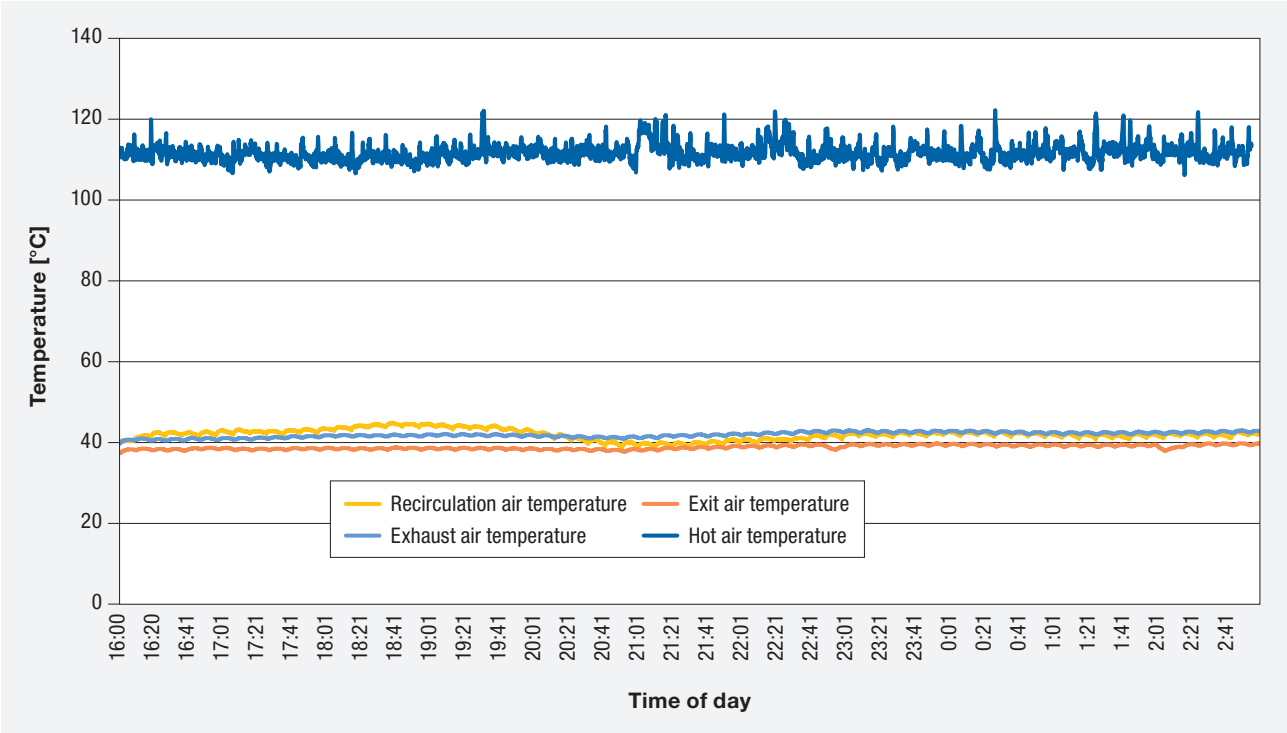

Figure 3:
Diagram showing the temperatures inside the dryer [°C]

Table 3:
Overview of measured and calculated values

Diagram reference (fig. 2)			
Date		**23-24 October 2014**	
Product		**Maize**	
Testing period		**4.24 p.m. to 3.27 a.m.**	
Duration		**12.05**	**h**
Product weights			
Dry product total		29.57	t
Wet product total		39.75	t
Ambient conditions			
Rel. ambient humidity	**1**	87	%
Ambient temperature	**1**	8.3	°C
Ambient pressure	**1**	992	mbar
Supply air temperatures			
Hot air	**2**	110.9	°C
Preheating air	**3**	191.0	°C
Air conditions			
Rel. exit air moisture	**4**	71	%
Rel. exhaust air moisture	**5**	68	%
Rel. recirculation air moisture	**6**	24	%
Exit air temperature	**4**	38.6	°C
Exhaust air temperature	**5**	41.7	°C
Recirculation air temperature	**6**	41.8	°C
Average maize moisture content			
Wet product moisture content	**7**	35.2	%
Dry product moisture content	**8**	12.9	%
Moisture removed		22.3	%
Throughput			
Dry	**8**	2.45	t/h
Adjusted to reflect standard conditions		2.74	t/h
Wet	**7**	3.30	t/h
Adjusted to reflect standard conditions		3.57	t/h
Water removal			
Reflecting standard conditions		0.84	t/h
Gas consumption (operating volume)			
Burner	**9**	76.9	m³/h
Specific to dry product		28.1	m³ of gas/t
Specific to wet product		21.5	m³ of gas/t

Diagram reference (fig. 2)			
Heating power/heating energy			
Burner	**9**	769.0	kW
Specific to dry product		281.1	kWh/t
Specific to wet product		215.3	kWh/t
Energy required per water volume			
Operating conditions		920.5	kWh/t
Operating conditions		3313.7	kJ/kg
Maize temperature adjustment		34.9	kJ/kg
Air temperature adjustment		115.8	kJ/kg
Standard conditions (5 °C)		962.3	kWh/t
Standard conditions (5 °C)		3464.3	kJ/kg
Differential pressure			
Exhaust fan	**4**	1460	Pa
Recirculation fan	**6**	435	Pa
Air flow rate			
Exhaust air (exit air)	**4**	37,000	m³/h
Recirculation air	**6**	16,000	m³/h
Natural air	**10**	24,800	m³/h
Cooling air	**11**	12,200	m³/h
Specific to dry product		13,523	m³/t
Specific to wet product		10,360	m³/t
Electrical output			
Average		33.7	kW
For 1 t of wet product		10.2	kWh/t

Note
Standard conditions: drying process from 35 % down to 15 % moisture at ambient conditions of 5 °C, 80 % relative humidity, 1013 mbar

Summary

These results suggest the Eco Dry STKL6-05/02 continuous-flow dryer by Bühler GmbH meets the standard (○) or higher requirements for passing the DLG-FokusTest based on Dryer Output and Energy Demand test criteria. The dryer under test is rated as generally suitable for drying maize.

Further Information

Further reports on tested drying systems are available to download at:
www.dlg-test.de/trocknung

Test execution

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DLG testing framework

Dryer Systems FokusTest (rev. 09/2013)

Field of activity

On-farm equipment and systems

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