EVALUATING THE PARAMETERS OF A MOBILE MAIZE DRYER IN PRACTICE

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Abstract

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The method of drying maize for grain has been recently employed on a large scale in the Czech Republic not only thanks to new maize hybrids but also thanks to the existence of new models of drying plants. One of the new post-harvest lines is a plant in Lipoltice (mobile dryer installed in 2010, storage base in 2012) where basic operational measurements were made of the energy intensiveness of drying and operating parameters of the maize dryer were evaluated. The process of maize drying had two stages, i.e. pre-drying from the initial average grain humidity of 28.55% to 19.6% in the first stage, and the additional drying from 16.7% to a final storage grain humidity of 13.7%. Mean volumes of natural gas consumed per 1 t% for drying in the first and second stage amounted to 1.275 m³ and 1.56 m³, respectively. The total mean consumption of electric energy per 1 t% was calculated to be 1.372 kWh for the given configuration of the post-harvest line.

Keywords: drying, maize, quality, energy intensiveness

Drying of maize for grain has become recently a much discussed topic in the Czech Republic not only thanks to the emergence of new maize hybrids but also due to the existence of new types of maize dryers. One of the new post-harvest lines is a plant in Lipoltice in the Pardubice region (mobile dryer installed in 2010, storage base in 2012) where basic operational measurements were made of the energy intensiveness of drying, and operating parameters of the maize dryer were evaluated. Drying of maize is much more complex than drying of other cereals. The reason is not only the high content of water at the time of harvest when the relative grain humidity is usually higher than 30%, but also the size and shape of the grain of individual maize hybrids. With the rapidly changing temperatures (grain heat-up to high temperature and subsequent quick cool-down), the grain is also more susceptible to the mechanical damage (Vitáček, 2011).

MATERIAL AND METHODS

The experimental measurements took place at the LIPONOVA, a.s. farm in Lipoltice, Pardubice region. The farm is situated at an altitude of about 350 m a.s.l. The Claas Lexion combine Model 550 with a 6-row adapter for maize was used for the harvest, which started on 6 October 2012. The last maize was harvested on 31 December 2012. The post-harvest line installed by AGROING BRNO, s. r. o. was equipped with a grain cleaner and a mobile dryer Model Schmidt-Seeger EcoDryFlex 18 designed for natural gas (Fig. 1).

The drying of maize had two stages: pre-drying from the initial mean grain humidity of 29.9% to 19.6%, and final drying from 16.7% to the final mean grain storage humidity of 13.7%. During the process of drying, records were taken of natural gas hourly consumptions and of the consumption of electric energy on a submeter. Samples of dried maize were collected, in which relative humidity (RH) was measured by the moisture content indicator Pfeuffer Model HE 50 on the dryer plant output as well as grain temperature by the digital thermometer with a measuring probe. Relative humidity of several grain samples was tested also in the laboratory of Mendel University in Brno.

Concurrently, relative ambient air humidity and temperature were measured and records of the
adjustment of dryer parameters by the operator were taken such as adjusted temperature of the drying medium and the time-out for emptying the dryer, which directly predetermined the plant performance.

An overview of plot acreages, sown hybrids and yields based on the weighing daily of the plant is presented in Tab. I; all other values were calculated by using standard procedures (Los, Pawlica, 2010; Vitázek, 2006).

Establishing the average relative humidity of all harvested grain (TARH) by using the method of weighted average.

\[
TARH = \frac{\sum TYwg \times RHh}{\sum TYwg}, \% \tag{1}
\]

where:

TYwg ........... Total yield per field of wet grain [kg]
RHh............ Relative humidity of grain at field at harvest time. [%]

Average grain yields per hectare (TAGYH) were calculated from sum of wet (at harvest RH) grain or dry (storage RH) divided by total sown area A.

\[
TAGYHwg = \frac{\sum TYwg}{\sum A}, \text{[kg.ha}^{-1}\text{]} \tag{2}
\]

\[
TAGYHdg = \frac{\sum TYdg}{\sum A}, \text{[kg.ha}^{-1}\text{]} \tag{2}
\]

Calculation of total dry matter, relative humidity of grain (RH), total water content at harvest and during storage describe for example Kováč (2012). According to these equations, the mass of dry matter of the grain can be calculated by

\[
MDMg = \frac{Mg \times (100 - RHh)}{100}, \text{[kg]} \tag{4}
\]

If we need calculate mass of water at corn at known RH, we use this equation (Ružbarský et al., 2004)

\[
Mw = MDMg \times \frac{RH}{(100 - RH)}, \text{[kg]} \tag{5}
\]

Hourly energy consumption of dryer was calculated from volumes of burned natural gas and electricity energy.

\[
q = \frac{VNG \times HNG \times 3600}{Mwrem}, \text{[kJ.kg}^{-1}\text{]} \tag{6}
\]

where:

VNG........... Volume of burned natural gas [m³]
HNG........... Energy content of natural gas 10.55 kWh. m⁻³
3600........... is constant for convert kWh to kJ
Mwrem........ mass of water removed during measurement [kg].

1: Mobile dryer Schmidt-Seeger Model EcoDryFlex 18 – General view (left) and a heat-exchanger detail (right) during the measurement – 14 January 2013
### Evaluating the parameters of a mobile maize dryer in practice

#### I. Maize plots and yields

<table>
<thead>
<tr>
<th>Plot</th>
<th>Area</th>
<th>Variety</th>
<th>Total yield per field of wet grain (kg)</th>
<th>Wet grain yield per hectare (kg ha⁻¹)</th>
<th>Harvest moisture content (%)</th>
<th>% actually dried</th>
<th>Total maize DM (kg)</th>
<th>Amount of water in grain at 14% (kg)</th>
<th>Dry maize stored at 14% (kg)</th>
<th>Dry (RH 14%) grain yield per hectare (kg ha⁻¹)</th>
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<tr>
<td>Za Peckova</td>
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<td>419 414</td>
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RESURTS AND DISCUSSION

Many factors condition the economy of the drying process. One of them is a correct technology of drying, i.e. dryer type and performance adequate to the plan of crops rotation and size of sown plots, heating medium, drying medium, drying schedule, adequate mechanization and automation of the whole post-harvest line, as well as a proper synchronization of the harvest and post-harvest parts of the line. In addition to energy consumption (natural gas and electric energy), total costs of drying include also some other items of which we can mention labour costs, depreciation or overhead costs; these may amount to as much as 40% of total costs (Los, Pawlica, 2010).

Deciding upon the purchase of a dryer we have to analyze these many factors and we should be able to compare various types of dryers. Perhaps the most important parameters to be compared include the specific heat consumption \( q (kJ.kg^{-1}) \) for the evaporation of 1 kg water (Mühlbauer, 2009), and the specific consumption of air for the diversion of 1 kg humidity \((kg.kg^{-1})\). In this respect, stationary high-performance dryers are preferred, which are usually equipped with heat recuperation and drying medium recirculation (Vitázek, 2011).

However, the building permission is sometimes difficult to obtain and the dryer has to be of a mobile type as it is in Lipoltice. Vendors of farm machines and agricultural operations very often use derived units – costs and consumption values converted to t%. Their informative value is much higher for them because an alternative to purchasing a dryer is the sale of wet grain to the vendor with the costs of drying to be detracted from the purchasing price and the purchased quantity to be converted to storage humidity. Deductions for humidity are expressed in CZK per 1 t% and usually range from 50–75.00 CZK per t%. The humidity deduction for a ton (1,000 kg) of maize at 30% RH will be \((30\% - 14\%) \times 50.00 \text{ CZK.t%}^{-1} = 800.00 \text{ CZK.} \)

As shown in Table \(1\), the average yield was 11,132 kg/ha.

<table>
<thead>
<tr>
<th>Plot</th>
<th>Area [ha]</th>
<th>Variety</th>
<th>Total yield per field of wet grain [kg]</th>
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<th>Harvest moisture content [%]</th>
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<th>Dry (RH 14%) grain yield per hectare [kg.ha]</th>
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<td>DELITOP</td>
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\[ \sum_{655.7} \]

\[ \sum_{8802} 230 \]

\[ \phi_{13} 423 \]

\[ \phi_{28.5} 428 \]

\[ \Sigma \sum_{105} 489 \]

\[ \Sigma \sum_{6289} 224 \]

\[ \Sigma \sum_{1023} 827 \]

\[ \Sigma \sum_{3130} 051 \]

\[ \phi_{11} 152 \]
at 3,002 kJ.kg\(^{-1}\) and 0.0967 kWh.kg\(^{-1}\) of electric energy. If we arrive at the use of grain thermal inertia. If we calculate a total consumption of 2.8% with the help of active ventilation with making use of grain thermal inertia. The specific heat consumption was measured and calculated to be 3,380 kJ.kg\(^{-1}\).

The above measured and calculated specific heat consumption values are within the ranges stated by other manufacturers of dryers (M–C MEYER q = 4,765 kJ.kg\(^{-1}\)) (Vitázek, 2011).

The two-stage technology of drying brings savings in the consumption of electric energy because the humidity of stored grain was reduced by about 2.8% with the help of active ventilation with making use of grain thermal inertia. If we calculate a total average heat consumption only for drying, we arrive at 3,002 kJ.kg\(^{-1}\) and 0.0967 kWh.kg\(^{-1}\) of electric energy.

If we express the average consumption per t%, then 1.275 m\(^3\) and 1.563 m\(^3\) of natural gas per 1 t% was consumed in the first and second stage of drying, respectively. The total average consumption of electric energy per 1 t% for the whole season was calculated to be 1.372 kWh. The total average consumption of natural gas per 1 t% for the given post-harvest line configuration was 1.119 m\(^3\).

**CONCLUSION**

Maize for grain has come to the limelight in the agricultural sector thanks to new hybrids and economically more affordable technologies. Later sowing dates and yields over 10,000 kg.ha\(^{-1}\) make it a good alternative to classic cereals as well as a guarantee for the enterprise economic stabilization. This is however conditioned by effective and high-quality drying as well as by conditions suitable for the drying. Our experimental measurements show that interesting for farmers may become also smaller-sized, mobile dryers.

Another question is the technology of drying in connection with the final product quality. The two-stage combined method of drying applied in Lipoltice and the taken measurements revealed also some risks. The high grain humidity (over 30%) causes problems in blocked transport routes and bridging in storage silos, which showed also during the experimental measurements. Another disadvantage was poor (low) final cool-down of grain on the dryer output where the temperature on the dryer output was 33 °C at the first measurement and 42 °C at the final drying, which was in direct contradiction with the technological requirements (max. by 5 °C as compared with the ambient temperature). The consequence was a locally increased grain temperature in the silo sometimes even up to 50 °C. The problem was solved by the continual operation of aerating fans and by exchanging the grain between the silos, which usually leads to the mechanical damage of grains. Furthermore, the high temperatures in combination with the high relative grain humidity (ca. 20%) form an ideal environment for moulds and storage pests.

**SUMMARY**

Evaluating of corn drying process energy consumption is very important due to high contents of water at harvest time in corn ordinarily 30% and higher. One of the new post-harvest lines is a plant in Lipoltice (mobile dryer installed in 2010, storage base in 2012) where basic operational measurements were made of the energy intensiveness of drying and operating parameters of the maize dryer were evaluated. The process of maize drying had two stages, i.e. pre-drying from the initial average grain humidity of 28.55% to 19.6% in the first stage, and the additional drying from 16.7% to a final storage grain humidity of 13.7%.

During the process of drying, records were taken of natural gas hourly consumptions and of the consumption of electric energy on a submeter. Samples of dried maize were collected, in which relative humidity (RH) was measured on the dryer plant output as well as grain temperature by the digital thermometer with a measuring probe. Relative humidity of several grain samples was verified also in the laboratory. Concurrently, relative ambient air humidity and temperature were measured and records of the adjustment of dryer parameters by the operator were taken to determine the plant performance. Mean volumes of natural gas consumed per 1 t% for drying in the first and second stage amounted to 1.275 m\(^3\) and 1.56 m\(^3\), respectively. The total mean consumption of electric energy per 1 t% was calculated to be 1.372 kWh for the given configuration of the post-harvest line. During the drying process 1,515,539 kg of water was removed, 270,040 kg (17.8%) from this by using active ventilation system. Its correspond to save 22581 t% haven’t been dried and theoretically save 58650 m\(^3\) of natural gas. Measurement show energy consumption dependency on ambient temperature too. The differences between day (12 °C) and night (6 °C) values are about 12%.
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REFERENCES


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