

## EXPERIMENTAL RESEARCH OF OZONE USING IN GRAIN DRYING

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### Abstract

Decrease of the consumption of energy resources is possible if grain is actively dry at low air temperatures, which also has a more favorable effect on a single grain. By using the new low-temperature technologies in grain drying, the same effect can be reached as by using grain dryers with high air heating temperatures. One of such technologies could be active drying of the grain layer at low air temperatures in ozone medium. Laboratory experiments show that the carried out moisture from grain is more efficient if active drying is performed using ozonized air. The presence of ozone in grain active drying process increases the amount of carried out moisture. Ozone when decaying to ordinary oxygen creates additional energy, which can be efficiently used in grain drying. As a result, grain drying is accelerated and energy consumption is decreased. Laboratory experiments prove the effectiveness of the presence of ozone in grain active drying process.

**Key words:** ozone, grain drying, grain active drying, ozonized air

### Introduction

One of the main tasks is storage of the grain yield with possibly less wastage. Harvesting grain during dry summer the moisture of grain quite often is over 20%, but in wet weather it can exceed even 25% (Chegev, 2006). For drying of grain having such moisture high consumption of energy and time is necessary. The optimal term from harvesting of grain till drying would be from one to two days. Often for the purpose of economy grain is not dried to the condition moisture (or not dried at all) that very essentially influences the quality of grain afterwards.

As drying of grain till the optimal moisture is a very expensive process consuming much energy, it is possible to decrease the consumption of energy resources if wet grain is dried at low temperatures. Usually heated air is used in grain drying. For heating of air either solid or liquid fuel, electric or solar energy is used.

In grain drying applying the technology of low temperatures the same effect can be achieved as using high air heating temperature dryers or heat dryers. One of such technologies could be active ventilation of the grain layer at low air temperatures in ozone medium. In order to state the influence of ozone in grain drying, laboratory experiments were carried out. (Lauva et al., 2005a; Lauva et al., 2005b).

### Materials and Methods

Experimental laboratory equipment was made up for simultaneous drying of grain using ozonized air and not using ozonized air (Figure 1). This equipment consists of ten grain cassettes; in each cassette a layer of wet grain of the density of approximately 20 mm is evenly refilled. The grain is weighed with electronic scales EW1500-2M with exactness ( $d = 0.01$  g). The wet grain is dried using ozonized air (position 5) and without ozonized air (position 6). For drying of wet grain the air is fed by means of a fan (position 4), where the desired air filtration velocity that is controlled by

an air flow velocity controller TESTO 400 (position 8) is set by a gradeless regulator. Ozone is produced by the ozone generator PRO 3,400 (position 2); in our experiments the amount of the produced ozone is  $7.7 \text{ mg m}^{-3}$  of air. As drying of grain is done using cold air, for regulation of the temperature of the in-flowing air before the fan a thermometer (position 1) is used and for regulation of the temperature before the grain cassettes thermometers (position 3) are used. The system is balanced by help of a throttle (position 7) in order to make the air filtration velocity through the wet grain with ozonized air equal to that without ozonized air. The moisture and temperature of the out-flowing air are regulated by help of the grain active ventilation regulation equipment GK-01 and air temperature sensors (position 9).

Artificially humidified grain was used as the object of the research. The initial moisture of grain was determined by the grain moisture meter Wille-55. At the end of the experiment for stating the amount of the carried away moisture the electronic scales EW1500-2M ( $d = 0.01$  g) were used.

### Results and Discussion

The experiments in grain drying were carried out at the air filtration velocity  $v = 0.2 \text{ m s}^{-1}$  simultaneously with ozonized air and air without ozone. In the experiment grain with the initial moisture  $W1 = 21\%$  and  $W1 = 27\%$  was used. The duration of drying was two hours.

The experiments showed that the efficiency of ozone in grain drying appeared at the average grain initial moisture ( $W1 = 21\%$ ) as well as at wet grain ( $W1 = 27\%$ ) (Figure 2). During two hours of drying carrying away of moisture from grain is more intensive in the first cassette and it gradually decreases until the tenth. In all cases the amount of the carried away moisture from grain due to the influence of ozone is larger than that without using ozone. The presence of ozone in the grain active ventilation process

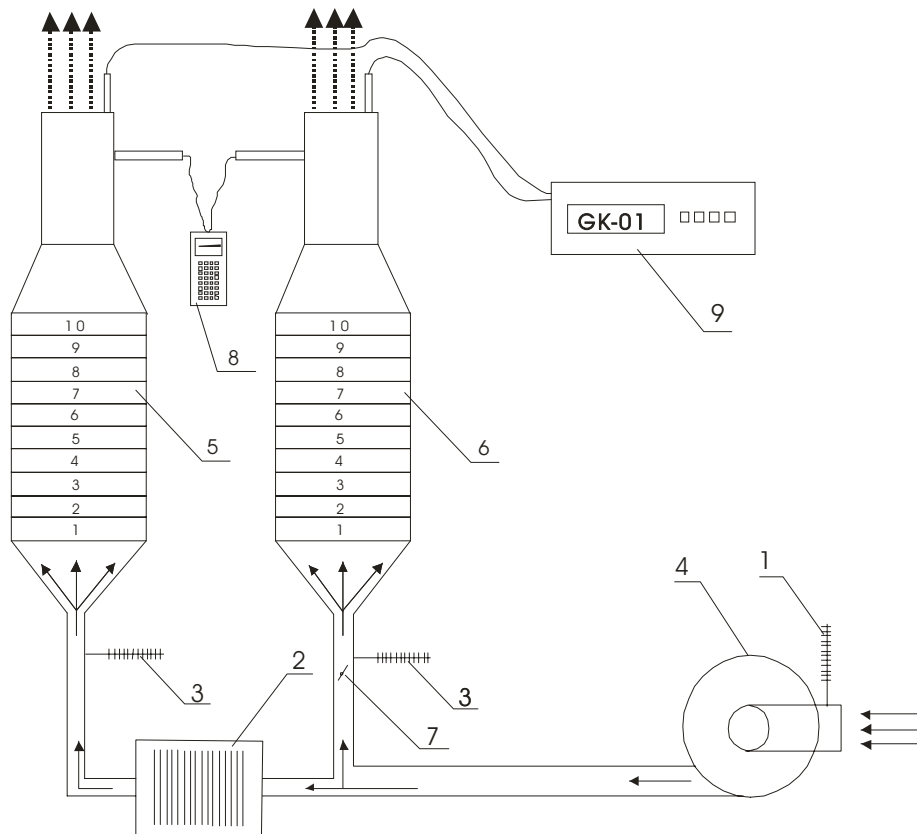


Figure 1. Experimental laboratory equipment for drying grain with ozonized air:

1 - thermometer for measuring the inflowing air temperature, 2 – ozone generator, 3 – thermometer for control of air temperature before the grain cassettes, 4 – fan, 5 – grain cassettes for drying of grain with ozonized air (10 pieces), 7 – throttle, 8 – air- flow velocity controller TESTO 400, 9 – grain active ventilation control devices GK-01 with air temperature – moisture sensors.

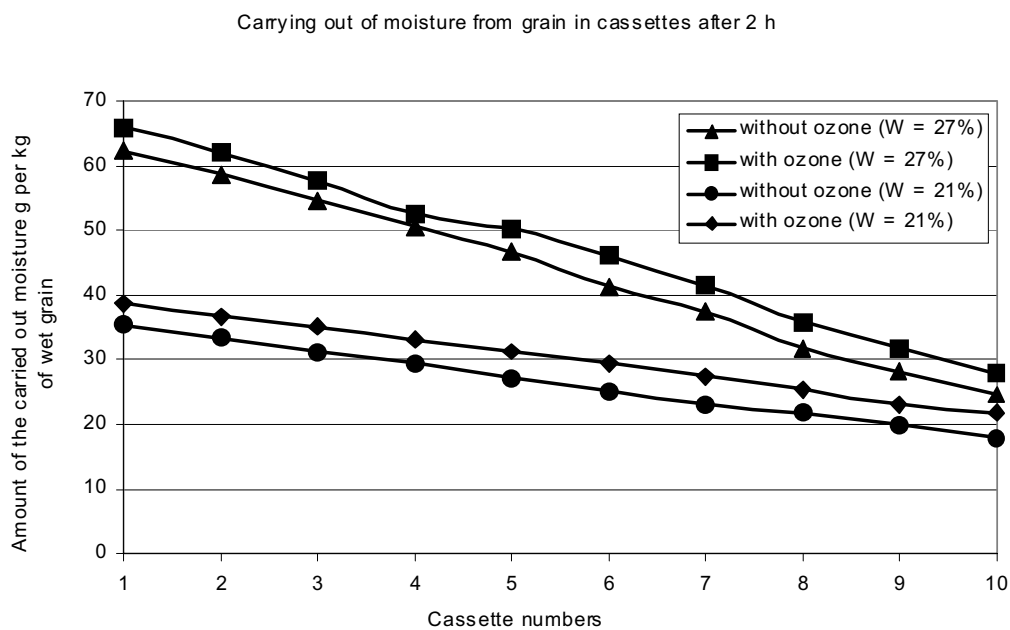


Figure 2. The amount of the carried out moisture (grams per kg of wet grain) after two hours drying grain with ozone and without ozone at the velocity  $v = 0.2 \text{ m s}^{-1}$  and at grain moisture  $W = 21\%$  and  $W = 27\%$ .

increases the carried away amount of moisture (Figure 3). It shows that from the initial grain moisture the efficiency of using ozone does not change essentially. It can be seen from these experiments that ozone does not influence the initial process of grain drying essentially, as at the beginning of drying the moisture from the space in between the grains and the moisture from the surface of grains is carried away. It can be clearly seen in Figure 4, where drying grain during the first ten minutes from the first grain cassette approximately 20 g of moisture per kg of grain are carried away, but already within the next 20 minutes - only about 10 g of moisture per kg of wet grain.

Figure 3 demonstrates that after two hours of drying wet grain ( $W = 27\%$ ) the amount of the carried away moisture is larger due to which the moisture of grain in the first cassette is approximately 22%, but in grain of average moisture ( $W = 21\%$ ) - approximately 18%. At the beginning of drying the moisture amount carried away from grain with higher moisture content is larger. When grain becomes drier a longer period of time is necessary for drying as moisture is carried away from the grain itself.

It can be seen from these experiments that ozone does not influence the initial process of grain drying essentially, as at the beginning of drying the moisture from the space in between grains and the moisture from the surface of grains is carried out. It can be clearly seen in (Figure 4), where drying grain during the first ten minutes from the first grain cassette approximately 20 g of moisture per kg of grain are

carried out, but already within the next 20 minutes only about 10 g of moisture per kg of wet grain.

Examining the moisture of the out-flowing air (Figure 5) it is seen that at equal initial out-flowing air temperature in the first 10 minutes of the process the moisture of air decreases because the moisture that is in the space between grains is carried away and only approximately after 20 minutes the process of drying starts inside the grain, then also ozone starts working as with decomposition of ozone energy is released that increases the temperature of the through-flowing air. A conclusion can be drawn that due to the influence of ozone, drying of grain occurs through the amount of the released energy, that is, with increasing of the drying agent temperature. Ozone does not essentially influence the initial process of grain drying while moisture that is in the space between grains is carried away, but its influence occurs after 20 minutes. The out-flowing air temperature starts to increase. With the air temperature increasing by 1 °C the moisture decreases by about 5%. The presence of ozone accelerates grain drying which results in the decrease of energy consumption. Laboratory experiments proved the efficiency of the presence of ozone in the process of active ventilation of grain.

Similar research has been carried out in Russia and Belarus (Trockaja, 1997, Golubkovich et al., 2005). Several hypotheses have been set out about the influence of ozone in the process of grain drying (Krivopishin, 1988). Using the active ventilation technology with ozonized air it is possible

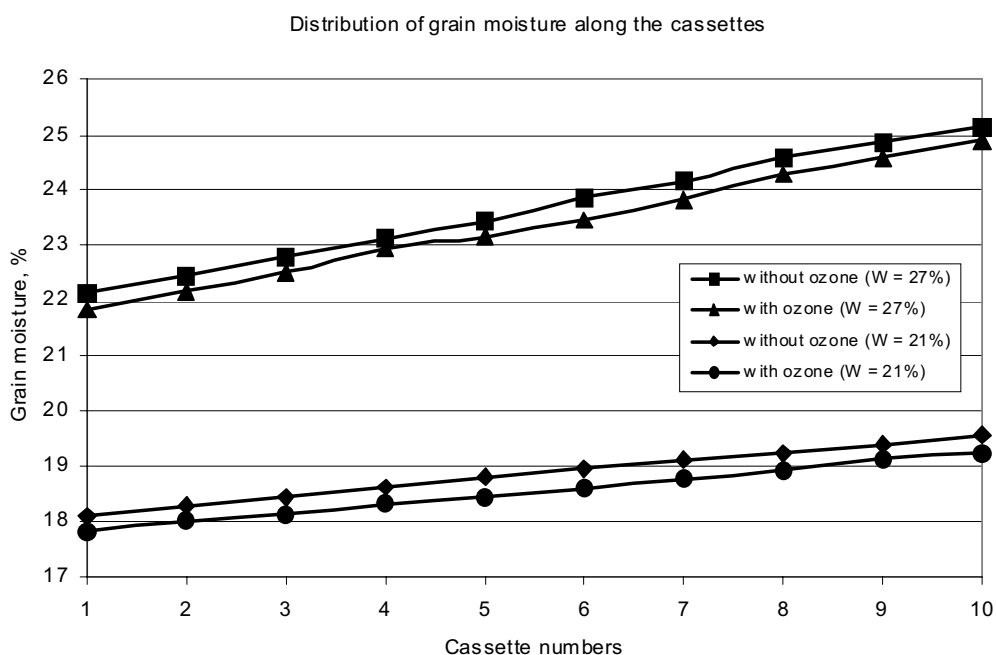


Figure 3. Distribution of grain moisture along the cassettes after two hours of drying with ozonized air and without ozonized air at different moistures of grain ( $W = 21\%$  and  $W = 27\%$ ).

Carrying out of moisture from grain according to time

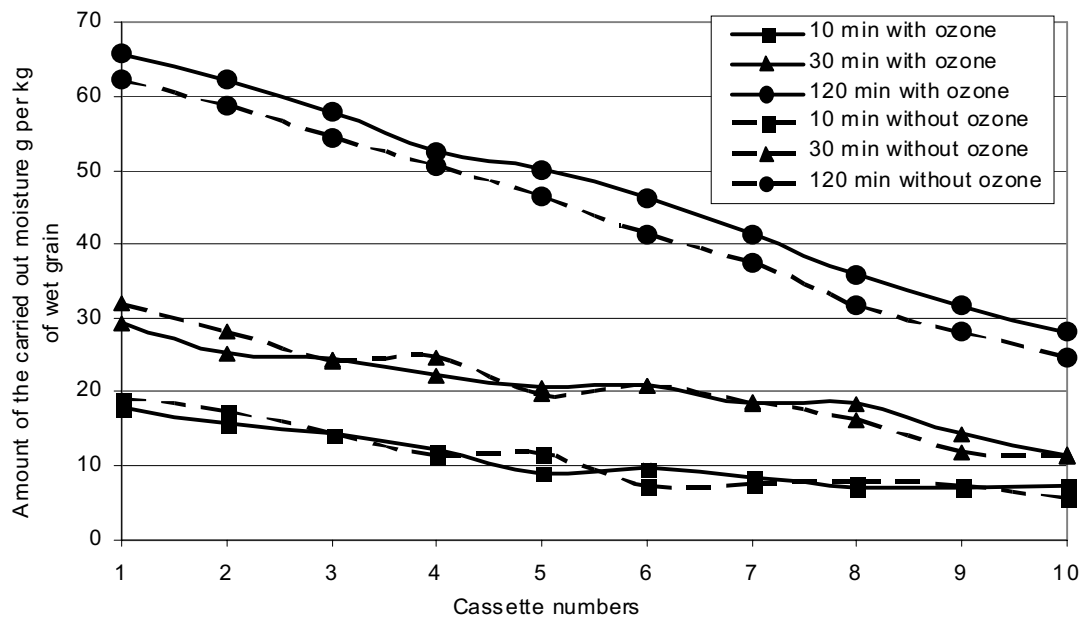


Figure 4. The amount of the carried out moisture g per kg of wet grain at different duration of drying (10 min., 30 min. and 120 min.) drying grain with ozone and without ozone,  $v = 0.2 \text{ m s}^{-1}$ .

that for carrying away of 1 kg of moisture from grain 20% less energy is needed compared to drying without ozone use (Bogatova, 2005; Golubkovich et al., 2005).

**Conclusions**

In the experiments it was proved that the presence of ozone in the process of active grain drying increases the

carried away amount of moisture. Ozone does not essentially influence the initial process of grain drying while the moisture in the space between the grains is carried away, but its influence occurs after approximately 20 minutes when the presence of ozone increases the grain drying in the result of what the consumption of energy decreases. With

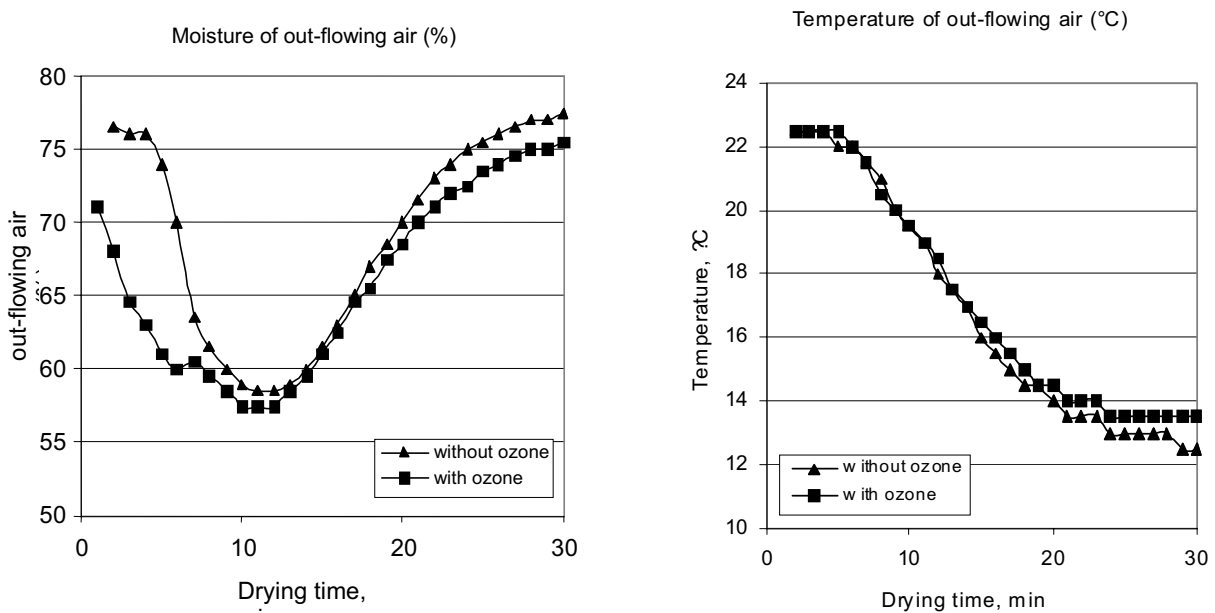


Figure 5. Moisture of the out-flowing air (%) and temperature °C ventilating grain with ozonized air and air without ozone at the velocity  $v = 0.22 \text{ m s}^{-1}$ .

decomposition of ozone back to oxygen, additional energy is obtained that allows using this energy in drying of grain.

The presence of ozone in the process of grain drying increases carried away moisture amount, but it does not have essential influence on the efficiency of ozone usage

from the initial grain moisture. Ozone does not influence the initial process of grain drying essentially as at the beginning of drying the moisture that is in the space between the grains and the moisture on the grain surface are carried away.

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