AUTOMATED CONTROL OF THE GRAIN DRYING PROCESS

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Abstract. A self-made ecological barn, which is situated on the "Mazkalnini" individual agricultural farm in Tervete Region (Latvia), was equipped with a grain storage and drying facility having computerized monitoring of moisture and temperature. The purpose of the equipment was to bring the condition of air to the desirable temperature and moisture by preheating it with the help of the sun and/or a furnace heated with wood.

Keywords: computerized monitoring, grain storage, heated with sun and wood.

Introduction

In the Latvian agriculture to cultivation grain the great value has always been allocated. Grain were grown up both for the food industry, and for technical needs, therefore increased requirements to the quality of production. In local meteorological conditions, not always there are conditions of gathering of a dry crop, therefore not always a possibility to hand over a crop in item of reception of production right after cleaning. Preparation of a crop for storage and the subsequent preservation grain gets especially important practical value for agriculture of Latvia. For grain preservation on places, it is necessary to clear and dry the product. The raised humidity leads to damage of grain in a period of 1-2 days. So, for example, at humidity of grain of 23 %, a degree of pollution of 15 %, in a period of short time the temperature of grain raises on 1-3 ˚C above the ambient temperature. In the case, at humidity of 24 % and the degree of pollution of 30 %, the temperature of grain quickly raises on 3-6 ˚C above the ambient temperature that leads to rotting. Researches show that damp grain is ideal environment for development of microorganisms. Including fungi which at vital functions produce concentrated toxins. Thus, concentration of toxins can sharply increase in grain. For example, if it is more than 5 mkg kg^{-1}, grain already is impossible to use as forage for cattle.

Another defect of traditional high-temperature drying of grain consists in damage of the capsule of grains. For preservation of the capsule of grains it is necessary to maintain temperature of drying not above 50-60 ˚C and to avoid humidity below 14 % [1]. In a number of works it is shown, that for reduction of time and temperature of drying, adds ozone (O_3) in air during drying [2-3].

The actuality of our work results from two factors: economic and ecological.

The economic factor. Large interest to reduction of expenses at agriculture, to reduction of a net cost of production and thus for increase of farm competitiveness. At present time it is a very important problem for small and bigger agricultural enterprises.

The ecological factor. The ecological factor dictates other requirements for technology of the product quality. These factors give controversial (often mutually exclusion) requirements to technology. The product which more conforms to ecological requirements, is more expensive and less profitable. Reducing the cost, the manufacturer reduces also the ecological conformity of production. Thus, the manufacturer is compelled to find a compromise between ecological compatibility and expenses. In work it was possible to combine both interests. At the same time to increase the ecological compatibility and to lower the cost.

Materials and methods

Our group carried out the control of temperature and humidity at five points of the grain storage and drying facility of the farm. The measuring system included the sensors of temperature and humidity «Dallas Semiconductor», model DS1923 [4]. The sensor is a metal tablet with the polymeric active layer registering humidity. The working temperature range of the humidity measurement is presented on Figure 1. The sensor control has built in memory 8 kB. Work with a sensor is possible in two modes: the first - reading of measurements and recording in the computer memory; the second - recording of the measurement in the sensor internal memory, with the subsequent disposable reading (for example, once a day). We made 10 measurements in 1 hour (1 gauging 6 minutes). The sensor internal memory has enough volume for gaugings in a period of several years. In our system five sensors included in a network in parallel are used. Everyone has a unique address that allows to distinguish it even at moving. The network had the length about 50 meters and connected sensors by means of a cable of twisted pair. Communication with a computer realized by RS232 protocol (the consecutive report of data transmission connected with COM by port of a computer). The scheme of the interface of communication with a computer is presented on Figure 2. Two permanent sensors were fixed (the first sensor in the supply channel of the warm air, and the second sensor – on the outside wall of the grain storage and drying facility). Three additional sensors could freely move through the bulk of the grain, and/or plunge into the layer of grain to the necessary depth. The schematic designation of the system is shown on Figure 3.

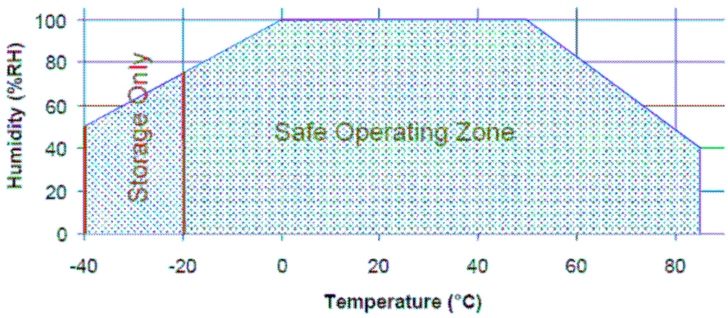

Fig. 1. **The working temperature range of humidity measurement**

Under the action of the sun the air in the pipe, which is covered with a black film, heats up to temperature that is by 1-3 ˚C higher than the temperature of the atmospheric air. By means of a ventilator the warm air moves into bins-containers 1, 2 and 3. In case of bad weather (cloudy weather, too low temperature of the atmospheric air) heating only by the sun is not sufficient for the drying of grain. In this case air can be additionally warmed up in the furnace located right just at the end of the pipe. The heat is produced by burning firewood in the furnace. Thus, there are two operating modes: the main mode in which the temperature of the air rises due to the solar energy, and the additional mode (under bad meteorological conditions) in which the necessary heat is added due to the air passing through the pipe from the wood furnace.

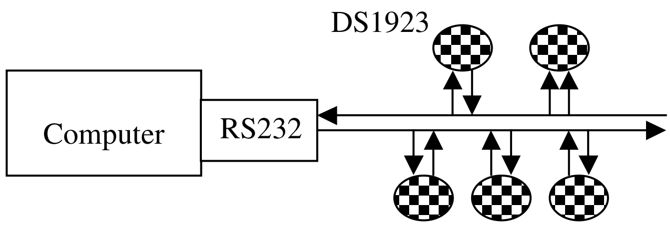

Fig. 2. **The scheme of the interface**

At calibration of the devices for climatic measurement, the mechanical measuring instrument of a stream of air (for finding of the minimal stream of air indispensable for work of sensor DS1923) has been used. Stability and accuracy of readings of sensor DS1923 depends on the speed of the stream of air above the containers with grain. In conditions of too high speed of the stream air the sensor cannot be stabilized, and its readings lose accuracy. With the objective of reduction of speed of the stream of air in zones directly adjoining to the sensor, the protective barriers partially extinguishing the speed of the stream through the sensor are used. For the control of humidity of the grain in the bunker, the measuring instrument of humidity with temperature probe Wile 66 has been used. Humidity of grain and the maintenance of water in air connects law (which represents function from atmospheric pressure and temperatures). Therefore, measurement of humidity of grain can be used for calibration of the sensor of humidity DS1923. The temperature of grain has been measured by means of the temperature probe attached to the measuring instrument of humidity.

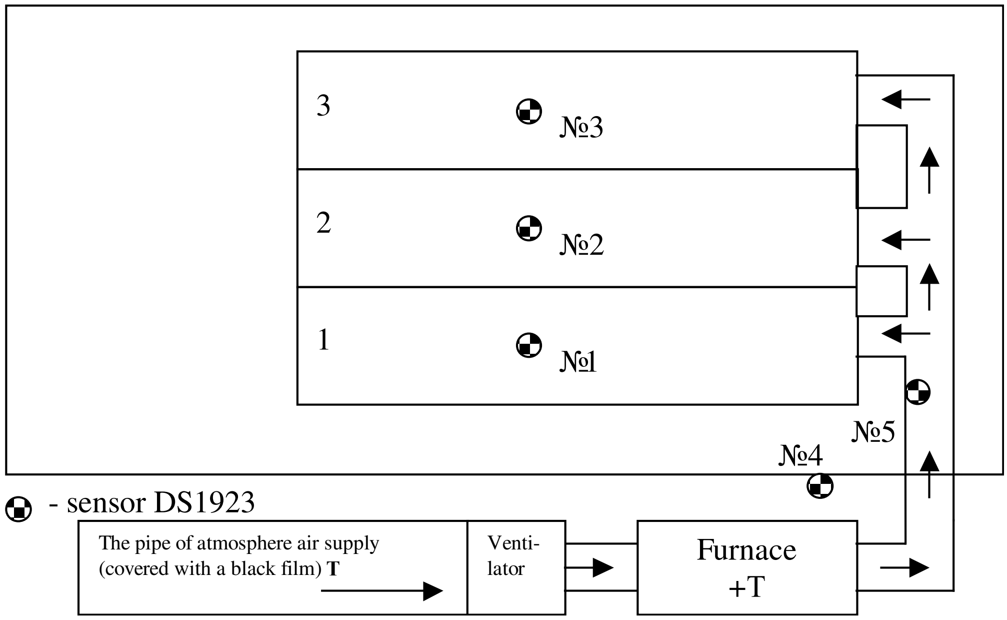

Fig. 3. **Schematic designation of system**

Results and discussion

The computer control opens new opportunities for the optimization of the drying process. The choice of an optimum strategy of drying occurs on the basis of the current objective technological parameters: climatic conditions of the environment, the temperature and humidity of the warm air in the channel and also the humidity of the grain. Owing to keeping low temperature of drying, the grain capsule does not burst, save capsule intact. Also grain keeps much valuable nutritious properties. The example of measurement is presented on Figure 4. From figure 4 the character of the process of drying during the work of the furnace is well visible. Humidity in the pipe goes down, but humidity of air in bunkers goes up, owing to intensive output water steam from grain. On this example, maintenance of humidity and temperatures at a desirable level, also the control over the process of drying of grain are shown. An opportunity to warm up air by means of the furnace, at optimum time. Another case of the control of drying is presented on Fig. 5 (the same designations, as on Fig. 4).

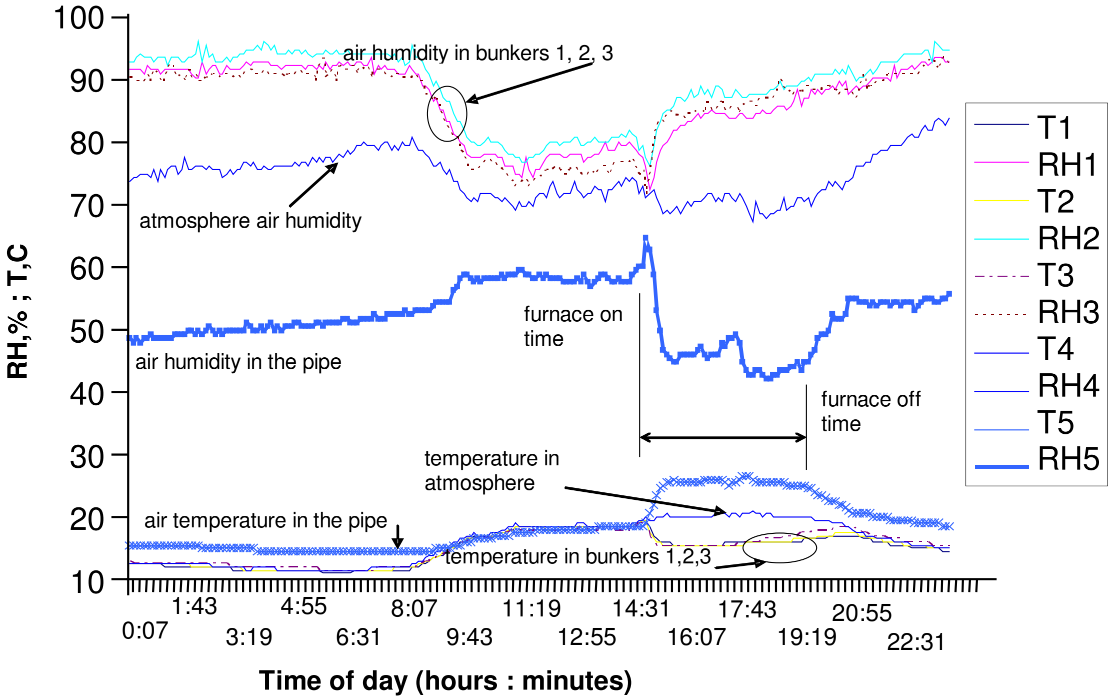

Fig. 4. **Example of operating conditions of drying grain**

Designations: T1, T2, T3 and RH1, RH2, RH3 - temperatures and humidity of air in bunkers No 1, No 2, No 3 accordingly. RH4 - temperature and humidity of atmospheric (air), T5, RH5-temperature and humidity of warm air inside of the pipe.

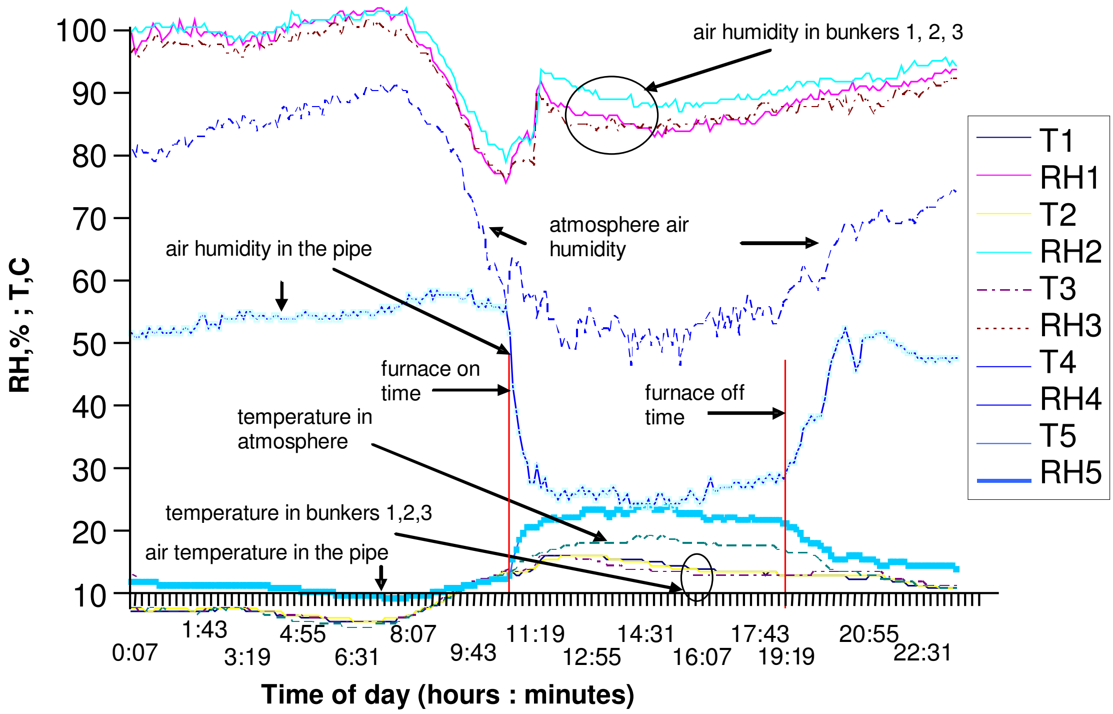

Fig. 5. **Example of operating conditions of drying grain**

Conclusions

The described method of drying grain by automated control using the sensors of humidity and temperature has the following advantages over the traditional high-temperature (up to 60 ˚C) technique of drying grain:

1. There is a possibility to make decisions on the basis of objective data, which leads to improved quality of drying.
2. The exact control of temperature and humidity ensures reduction of energy consumed during the drying process.
3. The low drying temperatures (up to 30 ˚C) allow gaining additional ecological advantages. The grain and its cover are not damaged under the influence of temperature.

References

1. Golubkovich A.V., Vigovskii Yu. N., Vigovskaja N.Yu., Malov A.N. The effectiveness of ozone - air gaseous mixture application to the drying of grain. Abstracts of the 26th meeting of Russian Workshop “Ozone and Other Environment Friendly Oxidants”. Moscow, Russia, December 18, 2003. p. 112-114.
2. Kartashevich S.M., Trockaja T.P. Energo-effective drying grains with ozone and active ventilation. Abstracts of the 26th meeting of Russian Workshop “Ozone and Other Environment Friendly Oxidants”. Moscow, Russia, December 18, 2003, p. 142-144.
3. Mendeza F., Maierb D.E., Masonc L.J., Woloshuk. C.P. Penetration of ozone into columns of stored grains and effects on chemical composition and processing performance. Journal of Stored Products Research, vol. 39 (2003) 33–44.
4. DS1923 Hygrochron Temperature/Humidity Logger iButton with 8kB Data Log Memory SPECIAL FEATURES (www.maxim-ic.com).