Electronic Temperature Meter for Moistened Onion Seeds

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**Abstract.** The seed material must meet the quality standard requirements. Such requirements include the germination energy and the germination capacity of onion seeds. The paper considers the electrotechnological process using alternating electric current of industrial frequency (AC IF) (f=50 Hz) for direct electric heating of moistened onion seeds before sowing. In this case, it is important to control the temperature at the upper level (55÷60 °C) in order to preserve the seed kernel for sowing. To determine the optimal parameters, experimental studies were conducted with a change in the main influencing factors. The main factors are the interelectrode distance, the exposure time of electrical treatment and electrical voltage. The main factors varied within the limits: interelectrode distance from 3 to 6 cm, time 30÷40 s, and voltage from 200 to 240 volts. The paper also presents the results of electrical measurements and the limits of permissible errors. In a small-volume cylindrical electrotherminator, continuous temperature control is achieved during electrical treatment of moistened onion seeds with alternating electric current of industrial frequency, and when the set (maximum) temperature is reached, the electrical receiver is disconnected from the power source.

**Keywords:** alternating electric current of industrial frequency, temperature measurement by electronic thermometer, automation and intellectualization of the measurement process

**INTRODUCTION**

The authors used an experimental drying unit for pulse infrared drying of vegetable seeds [1]. It was found that the seed temperature during pulse infrared drying of vegetable seeds varied from 34 °C to 40 °C, which had a significant stimulating effect on the seeds. The researchers studied the initial moisture content of seeds treated with vibrating infrared heat, the stimulatory effect of vibrating infrared drying, and the duration of the stimulatory effect over time [2].

**LETERATURE SURVEY**

Indian scientists Khatun et al. [3] (2021) studied the effect of temperature on onion seed germination. The study conducted experiments with onion seeds at 6 different temperatures (from 15 °C to 40 °C). According to the results of the experiments, different growth results were obtained, different temperatures were observed. These studies showed that there was a statistically significant difference between GP (germination percentage) and GR (germination rate). In the case of GP, the temperature range from 15 °C to 35 °C did not show a significant difference. They found that the temperature range of 15÷35 °C was better for seed germination than 40 °C. However, these studies did not study the issue of pre-sowing heat treatment of soaked onion seeds. Denmukhammadiev et al. [4] (2023) a new electrotechnological method is recommended, consisting of processing soaked onion seeds with electric current, followed by soaking the treated seeds in activated water for a certain time. In experiments using mercury thermometers, the temperatures of the outer and inner wall formed by layers of cotton bandage and soaked onion seeds in a dense (multilayer) winding on the surface of an indirect electric heating element were determined.

The work analyzed by Jaivignesh et al. [5] (2017) focuses on the study of one-dimensional heat transfer in a mixed cylinder. The study was carried out in a steady-state mode with constant material thermal conductivity. The heat equation was solved and boundary and initial conditions were set to obtain the results of the heat transfer simulation developed using the ANSYS 16.0 program. The values of size, temperature and convective heat transfer coefficients were entered into ANSYS 16.0 to generate the results. The use of such simulation electronic models allows the development of 3D-scale images in the form of models that are very close to the actual physical processes. Over the years, Denmukhammadiev et al. [6] (2023) have studied the electrophysical properties of vegetable seeds. Over the past 4 years, researchers have been closely involved in research on the thermophysical properties of seeds. In particular, they have experimentally studied the heat dissipation and thermal conductivity of seeds as dispersible granular materials. The authors have created a software for measuring and controlling the temperature of various objects. Also, the electronic temperature sensor for onion seeds DGU 11167, factory number A-01, was calibrated by the National Metrology Institute of Uzbekistan in accordance with the international calibration guide DKD-R 5-1 (08/2019). As a result, the accuracy of the electronic temperature sensor for onion seeds has improved [7].

It is known that many physical properties (dew point, density, electrical conductivity, dielectric constant, hardness and diffusion) are temperature dependent. In order to exploit or compensate for the temperature effect, it is necessary to measure it. The authors review three basic concepts of fiber-optic temperature measurement and present the current state of the technology and examples of applications. The principles of two-point fiber-optic temperature sensors are presented, including the internal (fiber Bragg gratings) and external probe (interferometric measurement). In these experiments, the temperature control of pipes is demonstrated [8]. Wheeler et al. [9] (2004) briefly describes some of the more common sensors. In one type of reflective sensor, the displacement of a bimetallic element is used as an indicator of temperature change. The response curve of such a sensor is also shown, taken from Kron (2000). In this case, the output signal is obtained in the form of a potential difference, and the input signal is a change in temperature. The light signal reflected from the surface of the bimetallic element creates a linear relationship between the potential difference and temperature (an inverse relationship is observed, i.e., as the temperature increases, decreasing values of voltage (V) are obtained). These types of sensors are used both as thermal switches and as analog sensors. It is known that reliable measurement of high temperature plays an important role in the aerospace industry, metallurgical industry and nuclear power generation. In these articles, researchers have reviewed the development of optical fiber high temperature sensors in the past decade. Mainly, the transition of the sensor principle from traditional optical fiber to crystal optical fiber is described and a comparative analysis is studied. The good performance and development prospects of crystal fiber optical sensors in the field of high temperature testing are described [10, 11, 12, 13, 14, 15].

Despite the high accuracy of fiber-optic sensors, their capabilities are limited by a minimum distance of 0.1 m (10 cm). And in the work, a device with an interelectrode distance of less than 6 cm is studied. Therefore, we stop at the use of electronic sensors.

**METODS**

It is known from the course of thermodynamics that heat in a certain medium is transferred in three ways: thermal conductivity, irradiation (radiation) and convection.

In the medium considered in this work (in layers of moistened onion seeds), two of the above methods predominate: thermal conductivity and convection. In the medium considered in this work (in layers of moistened onion seeds), two of the above methods predominate: thermal conductivity and convection.

Thermal conductivity occurs between the contacting layers of moistened seeds, and convection occurs in the layers of air filling the space of voids (usually this void is filled with air, an air-water mixture or water) between the seeds formed due to the unevenness of the seed surface. The primary cause of the appearance of heat inside a cylindrical vessel filled with moistened onion seeds is the Joule-Lentz energy released in the interelectrode space (between the outer and inner electrodes) when an alternating electric current of industrial frequency (AC IF) passes.

The electrical circuit of the compact electric heating device for treating soaked onion seeds with alternating electric current of industrial frequency (AC IF) is shown in Figure 1, where: 1 - DC voltage source (9 V); 2 - data processing unit; 3 - resistance; 4 - transistor; 5 - grounding device; 6 - semiconductor diode (VD1); 7 - DC voltage source (9 V); 8 - relay module; 9 - AC voltage source (220 V); 10 - ammeter; 11 - voltmeter; 12 - outer electrode (connected to the phase conductor); 13 - moistened onion seeds (symbolic image); 14 - temperature sensor; 15 - inner electrode (connected to the neutral conductor).

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| **FIGURE 1.** Electrical diagram of a small-sized electric heating unit for processing soaked onion seeds with AC IF |

When processing soaked onion seeds using the AC IF method, it is important to control the temperature of the processed seeds in a small-sized electric heating unit. Experiments show that heating seeds to 55–60 °C during processing increases germination and significantly reduces disease incidence. At the same time, the surface of the seeds is disinfected from surface infections. Due to this effect, the use of harmful pesticides used for chemical disinfection of onion seeds is limited. However, increasing the temperature above 55–60 °C can lead to a decrease in seed germination due to the negative impact of elevated temperatures in the seed embryo. Therefore, it is important to control the heating temperature of the seed layers using electronic temperature sensors.

**RESULTS AND DISCUSSIONS**

Several fiber-optik sensing concepts have been used in measuring temperature. These include reflective, microbending.

The following figure shows the electronic temperature control sensor (see Figure 2.).

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| **FIGURE 2.** Electronic temperature control sensor (Denmukhammadiev et al. [6] (2023)) |

In the research, we used Andijan Karatol onion seeds, which are cultivated in all regions of our Republic, that is, they are cultivated, early ripening, have a good harvest, are well stored, and are very fertile for greens. Also, electronic images of the sector-shaped physical model considered in the research work were studied in the Ansys 2023 R2 program.

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| **FIGURE 3:** Temperature measurement process using Ansys 2023 R2 software for a physical model of a sector filled with moistened onion seeds |

The results of the simulation model of the sectorial physical model are presented in Figure 3. The difference between the values obtained in laboratory conditions and using the Ansys 2023 R2 program is 1.5÷2%, that is, the values obtained using the program are more significant than in natural conditions.

The thermophysical properties of the onion seed layer (Andizhan Karatol variety) were determined depending on the humidity. The thermal conductivity of the onion seed layer increased over the entire range of humidity changes. The nature of the change in thermal conductivity can be explained by different forms of moisture contact with the material. When the onion seed humidity is 15%, the moisture fills small (micro) pores and, when saturated, passes into the intergranular space. In this case, the thermal conductivity becomes low, since air, the thermal conductivity of which is significantly lower than the thermal conductivity of the liquid, enters the pores of the material instead of water. In materials with high humidity, a sharp increase in thermal conductivity is observed due to surface moisture. When the seed humidity is more than 30%, their thermal conductivity is almost constant, since the moisture has left the material in such quantities that the rate of temperature change no longer decreases, but only the heat flow increases. In this case, the thermal conductivity of the seed layer is lower than the thermal conductivity of water and does not affect the specific properties of the material. An algorithm for the operation of an electronic sensor for monitoring the temperature of onion seeds has been developed (Figure 4.).

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| **FIGURE 4.** Operating algorithm of the electronic temperature control sensor |

According to the specified algorithm, when the system is started, the physical parameter of the seeds is entered first.

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| **FIGURE 5.** Graph of the temperature dependence of the time of treatment of onion seeds with IF AC  (1st moisture 22%; 2nd moisture 32%) |

Information about the temperature should be obtained using a temperature sensor: the temperature sensor ensures continuous measurement of the temperature by the measuring system during the processing of moistened seeds in the AC IF. As a result, the seed temperature begins to reach a certain (limit) value from a certain initial value, and the data receiving unit displays the temperature value on the LCD display. When the seed temperature reaches the specified value during this process, the system completely stops the process of seed processing in the AC IF. Otherwise, the processing continues.

From the characteristics it follows that the temperature of soaked onion seeds increases with increasing time   
(Figure 5), and the average temperature value reached in 30-40 seconds is in the range of temperatures that do not cause biological damage (negative impact) to the seeds.

# CONCLUSION

Electrotechnology of high-quality seed treatment by continuous temperature control with direct heating of soaked onion seeds in the IF AC installation increases the germination energy and seed germination, completely limits the use of harmful chemicals. Achieving continuous temperature control with high accuracy by means of an electronic sensor in this technological process created the initial conditions for intellectualization of the proposed method in the future.

# REFERENCES

1. S. Rudobashta and I. Grigoriev, Pulse infrared drying of vegetable, non-traditional and rare plant seeds, Ind. Heat Eng. **33**, 85–90 (2011).
2. S. Rudobashta, G. Zueva, and N. A. Zuev, Seed stimulation by oscillating infrared heat treatment, Ind. Heat Eng. **35**, 218–222 (2013).
3. I. Khatun and R. Hossen, Temperature effect on seed germination performance of a local variety of onion in Bangladesh, Plants Ecosyst. **1**(1), 27–30 (2021).
4. A. Denmukhammadiev, A. Pardaev, and E. Sobirov, A priori data on pre-sowing treatment and primary experiments on electric heating of onion seeds, E3S Web Conf. **434**, 01018 (2023). <https://doi.org/10.1051/e3sconf/202343401018>
5. J. Jaivignesh, Study of one dimensional conduction heat transfer for constant thermal conductivity through composite plane slab and in cylinder at steady state condition, Int. J. Mech. Eng. Technol. **8**(11), 456–465 (2017).
6. A. Denmukhammadiev, A. Pardaev, et al., Electronic-physical model that determines thermal conductivity of walls made of various materials, E3S Web Conf. **401**, 04038 (2023).
7. R. Baratov, A. Pardayev, et al., Software for a sensor for measuring and controlling the temperature of various objects, Certificate No. DGU 11167, Agency for Intellectual Property of the Republic of Uzbekistan (2021) (in Uzbek).
8. L. Hoffmann, M. S. Müller, et al., Applications of fibre optic temperature measurement, Estonian J. Eng. (2007).
9. A. Wheeler and A. Ganji, Introduction to Engineering Experimentation (Pearson Education, Upper Saddle River, NJ, 2004), pp. 301–312.
10. S. Yang, D. Homa, et al., Application of sapphire-fiber-bragg-grating-based multi-point temperature sensor in boilers at a commercial power plant, Sensors **19**, 3211 (2019).
11. J. Watson and G. Castro, A review of high-temperature electronics technology and applications, J. Mater. Sci. Mater. Electron. **26**, 9226–9235 (2015).
12. P. Childs, J. Greenwood, and C. Long, Review of temperature measurement, Rev. Sci. Instrum. **71**, 2959–2978 (2000).
13. S. Rizzolo, J. Périsse, et al., Real time monitoring of water level and temperature in storage fuel pools through optical fibre sensors, Sci. Rep. **7**, 8766 (2017).
14. A. Sang, M. Froggatt, et al., One centimeter spatial resolution temperature measurements in a nuclear reactor using Rayleigh scatter in optical fiber, IEEE Sens. J. **8**, 1375–1380 (2008).
15. S. Ma, Y. Xu, et al., Optical Fiber Sensors for High-Temperature Monitoring: A Review, Sensors **22**(15), 5722 (2022). https://doi.org/10.3390/s22015722