Machine for magnetic treatment of water used in baking

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Abstract. The quality of bakery products depends on properties of flour, water, and yeast. The most important factor in is quantity and quality of gluten, which depends on the gas-holding capacity of dough, and porosity, elasticity, and the volume of baked bread. The search for opportunities to improve quality of bakery products by affecting other components of dough, one of which is water is a relevant issue. Quantity and quality of water depend on the properties of dough and its products. Water is a solvent regulating intensity of enzymatic processes, both in yeast and in dough. Researchers and manufacturers expose water to various influences: degassing, heat treatment, ionization, sound processing and ultrasound. In recent years, the activation of natural water by electromagnetic fields has attracted attention of many researchers. The article presents a machine for electromagnetic treatment (EMF) of food solutions, in particular water used in baking. Due to some technical solutions, it was possible to reduce the heating temperature of water below 32°C, which is mandatory for kneading the dough. It can eliminate the ingress of toxic electrolysis products into the water. The machine can be easily assembled, disassembled and washed. It has an active component of power below similar devices used in heat power engineering. The machine can be used both in laboratory conditions and in industrial production.

1. Introduction

A literature review and a patent search showed that more than 100 types of machines are for treating water with constant and alternating electromagnetic fields (EMFs) [1-7]. EMF water treatment does not require chemicals, therefore it is an environmentally friendly method.

Gholizadeh and Arabshahi [4] developed a machine for electromagnetic treatment of water used for mixing concrete. Studying the strength parameters of samples of concrete mixed with magnetized and ordinary tap water, scientists have found that the average compressive strength of samples mixed with magnetized water is 23% higher than that of samples made using ordinary water. In addition, experimental samples of concrete showed increased ductility due to the influence of electromagnetic fields on ions contained in water.

Lipus and Dobersek [5] conducted laboratory studies of the magnetic treatment of water. During the experiments, they evaluated the effect of EMF on ions in two parallel experiments during a 3-week run of magnetized and ordinary tap water. Scientists came to the conclusion that the electromagnetic treatment of water can help control the scale that occurs in pipes. Similar results were obtained by Dobersek and Goricanc [6] in experiments on the treatment of geothermal water by the EMF. EMF water treatment influences such physicochemical properties of water as kinematic viscosity and
hardness [2]. Banejad and Abdosalehi identified a significant decrease in the rigidity of water treated with EMF - a change in the magnetic field induction from 0.075 to 0.1 T at various water flow rates [7].

The machine developed by the ARRI PTIMESKh was used as a prototype. It contains pipes, one of which is connected to a water source, and the second one - to a consumer. The nozzles are made of the material that cannot be used in food production. Water passes through the first pipe connected to a metal diamagnetic pipe, inside which a tubular core is installed with an annular gap with a through channel along the axis for water passage. The diamagnetic pipe is covered by a multi-turn magnetizing coil. The casing serves as a cylindrical magnetic circuit. The thickness of the magnetizing layer of water is not regulated [8].

The study of the machine for magnetic water treatment, including the machine developed by the All-Russian Research Institute of PTIMESKh, showed that for the device designed for magnetizing water used in bakery, technical solutions that eliminate or reduce the following disadvantages of the devices are required [8, 9]:

- a decrease in the heating temperature of the coils up to 30 °C, since the use of water with a temperature higher than 32 °C negatively affects quality of the test;
- elimination of toxic electrolysis products entering treated water;
- reduction of power consumption;
- simple assembling, disassembling and washing;
- automation of water supply in the batch of dough at a strict dosage, since quality of bread products depends on water properties and water quantity;
- an ability to adjust the thickness of the treated water layer, both at the same and different values of the magnetic field induction in the working clearances of the magnetic circuit.

2. Methods

Testing the machine for magnetic treatment of water used for baking was carried out on a machine (Figure 1) equipped with coils wound on aluminum sleeves (the number of turns \( n = 6200 \), the wire diameter \( d = 0.48 \) mm, the material -copper, the resistance \( R = 97 \) Ohm) with two axial cuts, both at constant and alternating current [3].

![Figure 1](image-url)

**Figure 1.** Schematic diagram of the K-50 kit, consisting of: \( W \) - wattmeter, \( V \) - voltmeter, \( A \) - ammeter, \( mV \) - millivoltmeter, \( L \) - magnetizing winding; \( D \) – sensor

Current, power, and voltage were measured. The heating temperature of the surfaces of coil windings was measured by GOST 2933-83. The wattmeter, voltmeter, ammeter, millivoltmeter had an accuracy class of 0.5 (error ± 0.5). The magnetic field induction was measured with a teslometer in the range from 0.01 to 0.06 T. Its probe was placed in the working gap. The time of exposure to EMF varied from 1 to 60 with and increment of 10 seconds.

Copper, aluminum, cast polyamide conduits were used. The value of the magnetic field induction and the active component of power were measured depending on the type of a material of the conduit at a voltage of 20 to 250 V with an increment of 50 V.
A series of laboratory tests was conducted to develop a magnetic water treatment machine used for baking.

It was theoretically calculated that to reduce the heating temperature of the coils, it is possible to make a double axial cut of the sleeve which should reduce the value of current and the heating temperature. The experimental results confirmed the theoretical calculations [10-11]. Figures 2–3 show the current-voltage characteristics of the coil of the electroactivator of water in direct and alternating current. The figures show that at the same voltages, the current value in the coils with axial sections of the coil liners is lower.

To test the dependence of the magnetic induction value on the material of the water conduit, identical water conduits of the same size were used: diamagnetic polyamide; paramagnetic aluminum; diamagnetic copper. The voltage varied from 20 to 250 V at an exposure of 3 seconds. The results of the experiment are presented in Table 1.

![Figure 2](image2.png)

**Figure 2.** Current-voltage characteristics of the coil of the water electroactivator (direct current)

![Figure 3](image3.png)

**Figure 3.** Current-voltage characteristics of the coil of the water electroactivator (alternating current)


| Voltage (V) | Copper conduit | Aluminum conduit | Cast polyamide conduit |
|------------|----------------|------------------|------------------------|
| 20         | 0.002          | 0.003            | 0.005                  |
| 50         | 0.005          | 0.005            | 0.01                   |
| 100        | 0.01           | 0.007            | 0.02                   |
| 150        | 0.016          | 0.02             | 0.03                   |
| 200        | 0.023          | 0.028            | 0.04                   |
| 250        | 0.03           | 0.030            | 0.05                   |

An analysis of the results allows us to conclude that the machine with a polyamide conduit requires less voltage to obtain a certain value of the magnetic field induction. With a cast polyamide conduit, an induction value of 0.03 T is achieved at 160 V; for a copper one - at 220 V, and for an aluminum one - at 230 V. In addition, with a polyamide conduit, the active component of power is reduced due to excluding demagnetization of the core.

Activated water should not contact with the metal of the poles, since the contact of water with an electrode can cause corrosion of the electrode [12-14]. It is necessary to treat water in a non-contact way by isolating one pole by applying a coating, teflon or food rubber to its surface. The other pole is insulated through the use of a polyamide conduit, as these materials can be used in food production water [3].

3. Results and discussion

Taking into account the results of the experiments and some other technical solutions, Fig. 4 shows the general view of the machine used in baking. The machine consists of pipeline made from molded polyamide 1, multi-turn coil 2, steel tubular core 3 with steps 4,5,6,7,8 extending beyond cylindrical magnetic core 9 with end caps 10. Before applying voltage to the coil by rotating end caps 10, the value of the working annular gap in magnetic circuits 15 and 16 and the thickness of the treated liquid layer are set.

When voltage is applied from the current source to plug connector 21 of magnetizing multi-coil coil 2, the pairs of poles are formed in ring gaps 15 and 16. Water passing through cavity 12 enters working annular gap 15 and is magnetized by one pair of poles. Through radial holes 18 of tubular core 3, it passes through hole 19. Through radial holes 18 at the other end of tubular core 3 and cavity 13 it enters annular working gap 16 of the magnetic system and is magnetized by a pair of poles. Water 13 magnetized by two pairs of alternating poles flows through the non-magnetic pipeline to the consumer (Figure 4).

The machine for electromagnetic water treatment is equipped with a ball valve and fitting couplings that ensure quick and easy connection to the water source and the consumer through food hoses. The quality of yeast and dough depends on water quality and quantity. This is especially important when conducting laboratory experiments. Therefore, we have developed an automatic meter for accounting for the consumption of water added to yeast or flour.

The meter for water consumption metering implemented on the AVR microcontroller on the AVR microcontroller ATmega8 is installed at the output of the device. As a water meter sensor, a standard reed switch sensor can be used. The reed switch inside the meter is designed so that the contact closes through each predetermined volume of water that has passed through the meter. For optical isolation of the microcontroller, the PSD-3R312 DC / DC converter and the TLP-181 opto-relay were used. The program inside the microcontroller counts the reed switch circuit. The accumulated values are displayed on the output data bus to which the liquid crystal indicator is connected.
4. Conclusion
The machine for treating water with an electromagnetic field allows you to:
- get treated water with an alternating magnetic field below 32°C;
- non-contact method of water treatment eliminates the ingress of electrolysis products into yeast and dough;
- the counter for water flow automatically controls the dose of water supply to yeast or dough;
- water treated at this installation with an electromagnetic field meets the requirements for water used in food production and, in particular, in baking;
- selection of a rational treatment mode requires additional tests.
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