

Development and Research of Bulk Material Moisture Meter

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Abstract – In this paper, ways of moisture meters enhancement are considered, with the purpose to use them in cereal-processing technologies. The paper suggests a new design concept of moisture meter for measuring grain moisture. Multiparameter measurement is the main principle of the given moisture meter. Capacitance method with correction for bulk grain weight and temperature is basic.

Key words – moisture meter, moisture, electric capacity, dielectric permittivity, bulk weight.

I. Introduction

Bulk material moisture measurement is a widespread procedure in many technological processes. It is used to measure moisture of ready-made bulk food products, semi-finished products, and products on particular stages of production. Moisture is a quality parameter of materials, its measuring can determine the net weight of materials, it has a great impact on the course of technological processes [3, 4].

Almost all branches of industry and agriculture apply the processes of drying and moisturizing to change the moisture of solid materials. Further studies are aimed at improving measuring devices for measuring moisture in the technological process of grinding in flour manufacturing. It is known that the grain is stored with low moisture content, and the process of grinding should be carried out with much higher moisture content. Therefore to increase moisture, the water is supplied to the flow of grain into the mill before grinding [1].

II. Presenting main material

The most popular method of grain moisture measuring is capacitance method of measurement.

1. The method consists in measuring transformer capacity, which is formed by two parallel plates around loaded grain. The difference between dielectric permittivity of the measured material and air is a necessary condition for the work of transformer [2].

2. Plates' capacity of measuring cell can be approximately expressed by the formula:

$$C \approx \varepsilon \cdot \frac{S}{d} \quad (1)$$

where:

ε – dielectric permittivity of the measured medium;

S – surface of plate;

d – distance between plates.

To determine the dielectric permittivity of grain, first it is necessary to find the capacity of capacitor when the capacity cell is empty:

$$C_0 = \varepsilon_n \cdot \varepsilon_0 \cdot \frac{S}{d} \quad (2)$$

where:

ε_n – dielectric permittivity of air, $\varepsilon_n = 1.0005$.

The dielectric permittivity of grain is calculated by the following formula:

$$\varepsilon_3 = \frac{(C_0 + C) \cdot d}{\varepsilon_0 \cdot S} \quad (3)$$

Analysis of this formula suggests that granulometric composition of bulk material influences the measurement result, as with its changing – the ratio between the contribution to the value of resulting dielectric permittivity of this index for the grains of material and air in between them will change.

Since the volume of the cell is constant, it is possible to amend the measurement result by changing the granulometric composition while weighting measuring cell. There are other uninformative parameters that affect the measurement result, particularly temperature changes of bulk material.

As you can see from formula 1, geometric size of the measuring cell affects the dielectric permittivity. Figure 1 shows comparative graphs of the dielectric permittivity of grain moisture with different geometrical parameters.

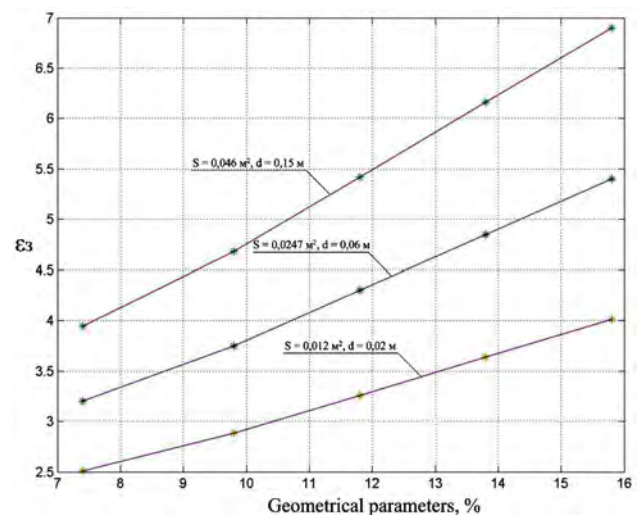


Fig. 1. Comparing graphs of the dielectric permittivity of grain moisture with different geometrical parameters

After analyzing the graphs, we can tell that dependence of dielectric permittivity from moisture does change its character with increasing the geometric size of capacitive cell, but the graphics are shifted upward on the vertical axis.

The potential of capacitive method of measuring moisture content of bulk materials can be fully implemented in the implementation of device conducting continuous measurement in the flow of material with simultaneous measurement of multiple parameters of this material – dielectric permittivity, bulk weight, temperature.

Block diagram of the multiparameter meter shown in Fig. 2.

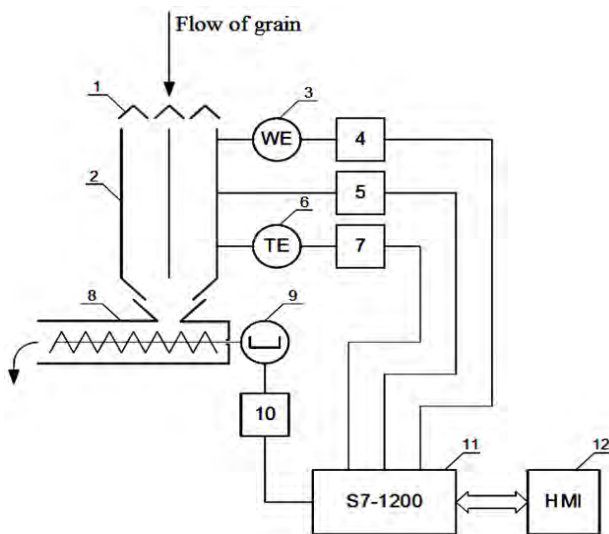


Fig. 2. Block diagram of the multiparameter moisture meter

Figure 2 contains the following components notes:

- 1 – flow divider;
- 2 – capacitive cell;
- 3 – weight sensor;
- 4 – matching unit of weight sensor and controller;
- 5 – transformer of capacity into unified current signal;
- 6 – temperature sensor;
- 7 – matching unit of temperature sensor and controller;
- 8 – screw conveyor;
- 9 – stepper motor;
- 10 – stepper motor control unit;
- 11 – programmable logic controller;
- 12 – operator panel.

Capacitive cell 2 is placed in the grain flow. Grain flows through the flow divider 1 to eliminate the flow influence on the process of cell weighing. Weighing is carried out by strain gauge 3, which signal is processed by block 4. The cell wall temperature is measured separately by thermometer 6, the signal is processed by transformer 7. To determine the moisture content of grain we measure electrical capacitance of cell when the grain flows through it. Capacity is processed by transformer of capacity into unified current signal 5. These signals are transferred to the programmable logic controller 11 which calculates moisture. Programmable logic controller can also perform service operations – periodic air blowing of unloading unit and unloading after termination of grain flow. Unloading of grain from the cell goes through the screw conveyor 8 driven by the stepper motor 9.

Programmable logic controller SIEMENS S7-1200 (Figure 3) chosen to implement this system in a compact package combines a microprocessor, input and output range. After loading the program, PLC contains the logic required to monitor and control devices. Programmable logic controller monitors the inputs and changes the outputs according to the logic of the program, which can include Boolean logic operations, count, timing, complex math operations, and communications with other smart devices [5].



Fig. 3. Programmable logic controller

The advantages of systems with digital control counting, compared with analogue and relay control systems, include:

- the possibility of implementing various control algorithms without changing the hardware of control unit;
- high speed data exchange;
- high integrity of data received;
- wide range of input and output signals;
- weight and size saving of control unit;
- improving reliability of equipment, easy reservation;
- ability to reconfigure control algorithms and control equipment;
- implementation only on digital microcircuit.

Conclusion

The block diagram of multiparameter grain moisture meter for continuous measurement in the flow was developed. The functioning algorithm for this device was developed, and depending on the change of device values from the change of bulk weight and temperature was experimentally removed.

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