

## **ELECTRICAL CAPACITIVE CONTROL OF THE PROPERTIES OF SUBSTANCES, TRANSPORTED BY PIPELINES**

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***Summary:** In the article considered the new class of three-terminal electrical capacitive means for control the composition of liquid and loose substances, including such transported by pipelines. Such converters are markedly different with accuracy and noise immunity of remote automated control of substances parameters. Considered and analyzed use possibilities of created design of measuring systems for automatic nondestructive integral and differential control the composition of flow substances – raw materials and semi-finished products of food production.*

***Keywords:** Automatic dynamic control, electrical capacitive remote sensing, flow-through sensor, integral and differential non-destructive control, accuracy, noise immunity, three-terminal.*

**Introduction.** It is considered that electrical capacitive sensors are too inaccurate and unstable, especially in remote measurements. However, the use of three-terminal schemes to measure the capacitance of the capacitor [1,2] for the first time allows you to create effectively shielded capacitive measuring converters, which now it's the opposite to be the most accurate and stable among all electrical measuring converters.

**Research methods.** In the new three-terminal system of capacitance measurement all capacitance measuring electrodes of primary transmitter (sensor) is combined with the low and the high potential terminals of the secondary capacity meter (transformer measuring bridge, or compensating bridge circuit). All other electrodes here for the first time do not attach to one of these input terminals of a meter capacity, but separately grounded, adding to the special its third input terminal. Therefore unstable distributed capacitances of the cable, connecting the sensor with a measuring device, already are not added to the useful capacity of primary measuring converter.

Capacity of cable and other possible parasitic capacitances in the sensor and on the screen of the system, adding to the conductivity of the bridge shoulders, can only slightly reduce its sensitivity, but not the relationship of his shoulders and therefore do not practically affect the useful input signal. Consequently, greatly increases the accuracy of measurements and for the first time for capacitive measurements in the new three-terminal system become real remote (up to hundreds of meters) measurements of capacity of the primary measuring converter.

In the three-terminal electrical capacitive system became possible not only to exclude of the so-called partial capacitances, if they are parasites, from the measurement result but also the effective creation of the desired configuration of

the measuring sensor fields. And it is very important to increase the accuracy of the measurements in the conditions, when the location of the transducer on the object of measurement and its configuration is strictly according to the external conditions. Or it is extremely necessary for implementation of the differential measurements of structure of the objects and substances.

In the new measuring system becomes possible implementation of non-indignating the controlled flow of the actual control of integral (that is averaged by volume), or differential (that is, certain items in the field of control) parameters of the controlled substance [3].

The industry is very needs in the automatic dynamic control of raw materials, which are served by pipelines in the production process. Therefore, it was designed the primary transmitter in the form of a simple tube sensor from three consecutive, electrically isolated among themselves, cylindrical metal parts of the pipe - electrodes. In such design of the transducer inside the controlled flow are absent any kinds of it parts. And therefore, the non-destructive testing also provides fully non-indignating the controlled flow measurements and the absence of a build-up of a controlled substance on the electrodes.

**Results and discussion.** As is evident, in the measurement of the important one is the most complete and uniform filling of the interelectrode space of the sensor by the measuring electric field, which will provide the most accurate and reliable control of the integral characteristics of the controlled substance (liquid, powder) in the pipeline. According to research of character of distribution of such a field inside the tube of the sensor, this occurs when the length of the middle grounded electrode of such primary transmitter is 0.3 of the diameter of the tube. The length of the measuring electrodes of the sensor must not be less than the diameter of tube, what with error, less than 0.1%, excludes the impact on the capacity of the converter real length of measuring electrodes. That is, in this case all settings of the sensor practically are determined by the diameter of the sensor and the length of middle grounding electrode that actually eliminates errors from inaccuracies fabrication and measurement of other geometrical sizes of electrodes and sensors as a whole.

Under the control of a particularly aggressive, abrasive or chemicals inner surface of the sensor electrodes is advisable to protect by a thin layer of dielectric with a dielectric permeability, close to the dielectric permeability of a controlled substance.

For differential, that is, a particle-size control of the geometrical sizes of the particles of mechanical impurities in the flow of the substance electrical measuring field in the cross section of the flow should be completely uniform and a maximally flat along the tube. For this, according to the research, the inner diameter of the electrode sensor should relate to the internal diameter of the pipeline, as of 1: 0.7. And this additional ring-shaped space between the inner surface of the cylindrical electrodes of the transmitter and the cylindrical surface of the controlled flow (with the thickness of 0.3 diameter of the electrode) it is necessary to fill in by dielectric material (by pipe) with dielectric permittivity, close to the dielectric permittivity of the basic substance-carrier of controlled

particle impurities. As during the operation of primary measuring converter composition (and, hence, the dielectric permittivity) of the substance-carrier may vary, the ring-shaped space is better to fill before the measurements by the same substance-carrier without controlled particle impurities. To hold the auxiliary substance (liquid or dry particle) should it limit by dielectric solid torus with thin walls of the material, dielectric permeability of which is close to the dielectric permittivity of the substance-carrier.

Such primary transmitter installed in the flow of the controlled substances allows to determine the sizes of particles-impurities, with their constant dielectric composition (for example iron), or, at constant size of the particles, and define their composition.

**CONCLUSION.** In contrast to the existing two-terminal capacitive measuring systems developed three-terminal measuring transducers - for integral and differential control the composition of the transported through pipelines substances - allow to carry out high-precision remote sensing. Such transducers do not contain any of the electrodes inside the pipe, providing so called non-destructive control of the composition of the transported substances. Such integral and differential automatic flow control is often necessary for various food and other manufactures. Such sensors can also be used to determine the start of the process of boiling of the liquid in the pipeline, which is very important for the safe operation of any technological equipment, including nuclear power plants.

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