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HEATING ELECTROLYTIC PRIMARY CONVERTER OF GAS HUMIDITY

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У статті розглянути питання поліпшення експлуатаційних характеристик (ресурс, інерційність, надійність) перетворювача вологості газів. Розроблений перетворювач, дозволяє вдвічі збільшити ресурс та зменшити його інерційність за рахунок розташування резистивної обмотки на поверхні перетворювача та шунтування його вологочутливим шаром. У цьому випадку резистивна обмотка виконує функції нагрівального елементу та електродів

The humid gas medium condition is characterized by its temperature, pressure and humidity which, in there turn, are characterized by the dew point temperature, partial pressure (elasticity) of water vapor, moist content, absolute humidity, relative humidity, enthalpy and humidity deficit. Having measured one of these hygrometric values, the rest are unambiguously determined from the table data of water vapor or moist air diagrams.

While gas medium pressure and temperature measurement may be considered the solved problem its humidity measurement is a problem far from completion now. There are a lot of known methods for measuring humidity of gas media based on different principles. But the overwhelming majority of these methods are non-promising and are not practically used, since they cannot meet high requirements to primary converters of gas humidity.

A heating electrolytic method is the most promising for measuring humidity of gas media. The primary converters of humidity of gas media based on this method of measuring are widely used in informational-measuring and control systems due to a number of advantages: interchangeability, operation simplicity, relatively broad range of measuring the values of relative humidity of the controlled gas, relatively low error of measurement and lag, reducibility of metrological characteristics after regeneration of moisture-sensitive layer, as well as its operability in dusted and explosive media.

A heating electrolytic hygrometer has evolved from the instruments for measuring one of metrological parameters of the atmosphere air to the means of obtaining information on technological processes of national economy and scientific investigations. Measuring instruments and regulators of heat-humidity condition of the controlled gas medium are created on their basis.

An operation principle of the heating electrolytic primary converter of gas humidity is based on reaching hygrothermodynamic equilibrium state between the elasticity of water vapor evaporated by the surface of moisture-sensitive layer under its heating and water vapor elasticity in the controlled gas medium [1]. Equilibrium temperature, at which the hygrothermodynamic equilibrium of water vapors elasticity takes place, is the parameter which helps to determine the water vapor elasticity in the controlled gas medium.

Fig. 1 presents a block-diagram of the heating electrolytic primary converter of gas humidity which consists of a frame 1, fabric base 2, electrodes 3 and thermosensitive element 4 connected with the measuring instrument 5. The heat-sensitive element is placed inside a frame in a form of a tube and has a thermal contact with moisture-sensitive layer. A fabric sleeve of glass fibre (a base) is put on the tube, and two electrodes are arrangedon the sleeve surface, they are connected with a supply source 6.

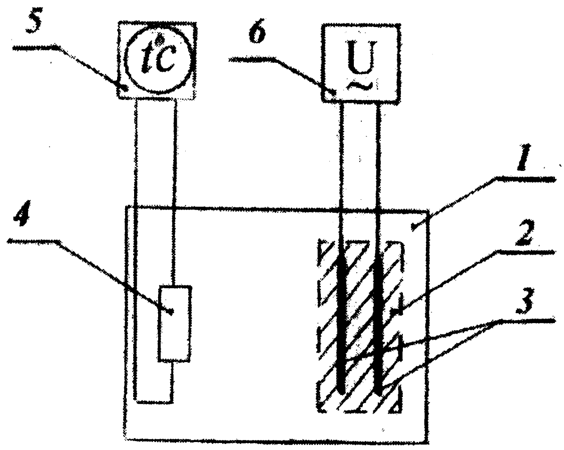

Fig.1. **Block-diagram of gas humidity converter**

When preparing a converter for operation a fabric base is impregnated with water solution of hygroscopic salt, for example, lithium chloride, and electrodes are connected with the supply source circuit. When current passes through the circuit of electrodes through the salt solution the latter is heated and evaporates the excess of solvent, as a result a moisture-sensitive layer is formed in the fabric base volume and on its surface; the layer consists of crystalline hygroscopic salt and electrolyte on its surface. After completing the transition processes of sorption and desorption of water vapors, an equilibrium temperature of moisture-sensitive layer is set; the hygrothermodynamical equilibrium of elasticity condition of water vapor between the hygroscopic salt and controlled gas comes at this temperature.

A shortcoming of the described above converter of gas humidity is its comparatively low resource (the period of the converter operation without regeneration of moisture-sensitive layer) as a result of proceeding of electrochemical processes of decomposition of the hygroscopic salt on electrodes surface when electric current passes through the electrolyte in the operation period for maintaining equilibrium temperature of moisture-sensitive layer, which is kept automatically. Especially intensive decomposition of the hygroscopic salt takes place in the process of forming the moisture-sensitive layer, since the maximum current (1.3 A) passes through the electrolyte for the solvent evaporation, and as a result the converter resource is reduced by ~ 8 %.

In the work [2] the author proposes to use an additional heat source with the purpose of increasing the resource of the heating electrolytic converter of gas humidity; this additional source is a resistive heating element placed between a heat-sensitive element and moisture-sensitive layer, isolated by the insulating film from the latter. Fig. 2 presents a block-diagram of the converter with additional heat source where: 1 - a frame, 2 - fabric base; 3 - electrodes, 4 - resistive heating element; 5 - heat-sensitive element; 6 - measuring instrument; 7 - source of supply; 8 - current regulator in the chain of heating of the moisture-sensitive layer; 9 - a switch.

The converter is prepared for operation as follows. The converter base 2 is impregnated with water solution of lithium chloride. Then in the chain of the heating element 4 we set the current value sufficient for heating the salt solution to the temperature at which the solvent evaporation from the base is provided, as a result a moisture-sensitive layer is formed in the volume and on the surface of the latter; the layer consists of lithium chloride crystals. Then a nominal feed current is applied to electrodes, and in the chain of heating element such current is set which is sufficient for Fig

maintaining the temperature of moisture-sensitive layer by the heating element; of this temperature corresponds to the equilibrium temperature of the lower limit of the range of the

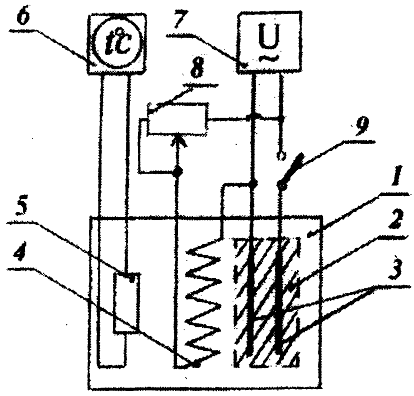

Fig.2. **Block-diagram of gas humidity converter with resistive heating element**

measured gas humidity. When the transition processes of sorption and desorption of water vapors is completed, the equilibrium temperature of moisture-sensitive layer is established, the controlled gas humidity being determined from this temperature value.

In the described design of the method of operation of heating electrolytic converter of gas humidity the converter resource is increased at the expense of removing the processes of decomposition of the hygroscopic salt during the formation of moisture sensitive layer, since the solvent evaporation from salt solution is not performed by current passing through the solution, but by heat released by additional heat source. The resource increase is also favored by the constraint of current passing through the electrolyte in the converter operation period, since the moisture-sensitive layer is heated by additional heat source to the temperature which corresponds to equilibrium temperature of the lower level of range of gas humidity measuring. However, such a constructive decision of placing the resistive heating element is not rather successful, since the converter lag increases because in the period of the converter operation the resistive winding and electro-insulating pad are heat-insulating interlayer between the moisture-sensitive layer and heat-sensitive element. Certain limitation of the converter resource is also a shortcoming, since the heating element in the period of its operation heats a moisture-sensitive layer only to the temperature which corresponds to equilibrium temperature of the lower level of the range of gas humidity measurement, and the moisture-sensitive layer is heated in the whole set range of humidity measuring by current passing through the moisture-sensitive layer, as a result there occurs electrochemical decomposition of the hygroscopic salt on the surface of electrodes. Low reliability of the converter because of the complicacy of its production and operation may be also considered its shortcoming.

A primary electrolytic gas humidity converter has been developed by results of the above investigations. In this converter the resistive heating element is winded on the surface of the moisture-sensitive layer with turn-to-turn interval and shunted moisture-sensitive layer.

In this case the resistive heating element is winded on the surface of the moisture-sensitive layer with turn-to-turn interval and shunted moisture-sensitive layer. In this case the resistive heating element having a thermal and electric contact with the moisture-sensitive layer functions as a heating element and electrodes due to turn-to-turn voltage drop.

Fig. 3 presents a block-diagram of gas humidity converter with resistive heating element, shunted by moisture-sensitive layer. A glass sleeve *2* is put on the surface of the frame (tube) 7, heat-sensitive element *4* being set inside the tube. A resistive heating element *3* of nonelectroinsulated material, e.g. high-resistance wire, carbon thread, etc., with turn-to-turn interval is winded on the glass sleeve. Ohmic resistance of the resistive heating element and its supply voltage, depending on the required humidity measuring range, are chosen in such a way that the moisture-sensitive element, before its impregnation with salt solution, was heated by the heating element to the equilibrium temperature corresponding to the lower limit of the preset range of gas humidity measurement, while the supply voltage of the resistive winding could provide the turn-to-turn voltage drop sufficient for the normal operation (depending on the required lag) of the converter.

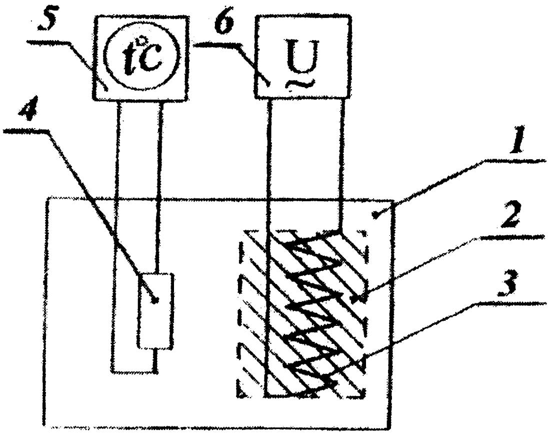

Fig. 3. **Block-diagram of gas humidity converter with resistive heating element shunted by moisture-sensitive layer**

The converter is prepared to the operation in the following way. The gas humidity converter is set up in the place of its operation, and its glass sleeve is impregnated with water solution of lithium chloride, e.g., dipping it in the test glass. Then a portable case (jacket) with built-in autonomous heating element is put on the converter. Heat released by the heating element in the jacket heats water solution of hygroscopic salt in the converter glass sleeve. The solvent is evaporated, and a moisture-sensitive layer consisting of crystals of hygroscopic salt is formed in the interfibre space of the glass sleeve. Then the jacket is taken-off, and the supply source *6* is switched on, as a result, the moisture-sensitive layer is cooled to the temperature equal to equilibrium temperature of the lower limit of present range of gas humidity measuring. In this case, lithium chloride crystals sorb water vapor from the analyzed gas and form the conducting water solution (electrolyte) on the surface. When current passes through the electrolyte, as a result of turn-to-turn voltage drop, the moisture-sensitive layer is heated, and when the transition processes of sorption and desorption of water vapors is completed, there comes a hygrothermodynamic equilibrium state of elasticity of water vapors between the moisture-sensitive layers an controlled gas medium.

The equilibrium temperature is measured by a measuring instrument *5* with the help of heat-sensitive element *4*. The required parameters of gas humidity are determined from the values of equilibrium temperature with the help of the corresponding calibration characteristics.

Conclusions

The humidity converter lag decreases as a result of the arrangement of the resistive heating winding in the moisture-resistive layer, since the moisture-resistive layer is placed just on the surface of the heat-sensitive element. The shunting of the resistive heating winding by the moisture-sensitive layer increases the converter resource as a result of lowering current passing through moisture-sensitive layer in operation period, since the amount of heat released by the resistive winding increases with humidity of the controlled gas medium in connection with the fact that the total current in the resistive winding consists of current determined by ohmic resistance of the resistive winding and by its supply voltage (constant values), a current passing through the moisture-sensitive layer (variable value). The converter reliability was increased due to the simplicity of its structure, manufacturing and operation.

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ВИКОРИСТАННЯ ПРОГРАМНОГО КОМПЛЕКСУ IMPACT ДЛЯ НЕЛІНІЙНОГО ДИНАМІЧНОГО АНАЛІЗУ МЕТОДОМ СКІНЧЕННИХ ЕЛЕМЕНТІВ ПРОЦЕСУ ПОДРІБНЕННЯ ПОЛІМЕРНИХ МАТЕРІАЛІВ У РОТОРНИХ ДИСКОВИХ ПОДРІБНЮВАЧАХ

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Розглянуто особливості систем що використовують метод кінцевих елементів для вирішення інженерних та наукових задач. Наведено опис принципу роботи та можливості програмного продукту Impact, що використовується для нелінійного динамічного аналізу методом кінцевих елементів процесу подрібнення полімерних матеріалів у роторному дисковому подрібнювачі

Будь-яка інженерна розробка повинна задовольняти визначеним критеріям. Відповідність цим критеріям можлива тільки при комплексній оцінці впливу геометричних параметрів, властивостей використовуваних матеріалів і умов роботи виробу. Проведення такого аналізу з урахуванням усе зростаючої складності інженерних розрахунків можливе лише із застосуванням найефективніших сучасних комп'ютерних технологій. Задачі з невеликою кількістю факторів доцільно вирішувати аналітичним способом. Але що робити зі складними задачами, в яких кількість невідомих дуже велика?

Для вирішення таких задач використовуються чисельні методи, в основу яких покладена заміна розрахункової моделі з безперервним розподілом параметрів і нескінченним числом ступенів свободи