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Й. Й. Білинський
В. В. Красносєльський

MEASUREMENT OF HUMIDITY MEASUREMENT CONTROL NATURAL GAS BASED ON THE DEW POINT METHOD

Вінницький національний технічний університет

Анотація

В роботі досліджено існуючі засоби вимірювання вологості природного газу та запропоновано засіб вимірювання вологості природного газу на основі НВЧ методу точки роси.

Ключові слова: природний газ, вологість, метод точки роси, НВЧ.

Abstract

This work investigates existing means of measuring the natural gas humidity and proposes a means of measuring the natural gas humidity based on the microwave dew point method.

Keywords: natural gas, humidity, dew point method, microwave.

One of the most important tasks in the transportation of natural gas is to evaluate its quality, especially for humidity. The concept of "quality of natural gas" means the conformity of its composition with certain values of its basic characteristics, such as calorific value, moisture content and the presence of corrosion-active components (hydrogen sulfide, carbon dioxide, etc.).

Natural gas extracted from wells is subject to compulsory preparation prior to transport to the end consumer. This is due to the fact that natural (or associated petroleum) gas, being a complex mixture of different hydrocarbon components, also contains various impurities, which have a significant impact on the process of gas transportation through the main pipelines. The most significant are impurities of water, the presence of which is unacceptable for many reasons. Water vapor increases the cost of pumping, impairs the quality of the final product, and accelerates corrosion of the pipeline. But the most serious result is hydration, which occurs under certain conditions of transportation. As a result, the throughput of the gas pipeline is reduced (to a complete blockage), filters, taps and compressors are damaged. The formation of hydrated plugs in pipelines is considered a very serious accident, the elimination of which is an extremely costly measure. The cost of eliminating just one large hydration plug, even in a location accessible to vehicles, can be several tens of thousands of dollars.

The conditions of transportation do not require complete removal of moisture from natural gas, but require only maintaining the required dew point of the moisture and hydrocarbons, which does not transfer the gas, while reducing its temperature, from an unsaturated state to a saturated one, in which the condensed phase can be separated from its composition. To prevent these processes, it is necessary to accurately predict and determine the thermal and hydraulic modes of the gas pipelines, the optimum temperatures of the dew point of the moisture and the hydrocarbons of the natural gas being transported. [1].

As existing means of measuring the humidity of natural gas, due to the low level of pre-validity of the results, it loses its expediency, low speed of measurement and impossibility of integration of these means into the general system. At the enterprises of the gas industry of Ukraine today there is an urgent question of measuring instruments that can determine several quality indicators at the same time, namely: the temperature of dew point, gas components and the temperature of the beginning of formation of crystalline hydrates, ice.

Therefore, the need and importance of new methods and tools for the accurate and rapid determination of the natural gas humidity determined the choice of the topic of the study. Creation of a new modern system of measurement of natural gas quality indicators, ensuring accurate, fast and reliable determination of humidity, taking into account impurities in its composition. Therefore, the topic of the study is relevant. The dew point method, which has been used for many years as an accurate laboratory method for determining humidity, has become one of the main methods for the automatic control of humidity and other gases in recent decades. It is widely used in industry, meteorology, the study of the atmosphere with the help of aircraft. In the practical implementation of the method, the condensation process is formed on the surface of the cooled solid ("condensation pad"), which we will hereafter call a mirror. The refinement and automation of mirror cooling operations and the detection of condensate on its surface have transformed dew point determination into a continuous, low-inertial measurement process.

Advantages of dew point hygrometers - large measurement limits, up to low temperatures (-100 ° C and below), over a wide range of temperatures and pressures, covering low negative temperatures and high pressure, satisfactory accuracy over the entire measurement range, initial value, conservative with respect to to the temperature of the gas being analyzed, the ability to calibrate by temperature rather than humidity.

Their main disadvantages are some design complexity (the presence of a cooling device), a decrease in the measurement accuracy with increasing relative humidity, the dependence of the measurement result on the nature and condition of the mirror surface, on its contamination.

Measuring the temperature of the dew point is reduced to the following operations: 1) reducing the temperature of the mirror surface; 2) fixation of the moment of condensation (in the form of dew or ice) on the working surface of the mirror; 3) temperature measurement of this surface [1].

The degree of automation of these operations determines the type of hygrometer. In non-automatic hygrometers all operations are performed by a person. Semiautomatic hygrometers are characterized by the fact that one or two of these operations are performed automatically. Finally, automated devices automate all operations associated with the measurement process. The first two types include discrete-action devices, the third - hygrometers designed for continuous measurement and regulation. There are a large number of dew point hygrometers of all these types, differing in their structural features and the work of individual parts.

Non-automatic dew point hygrometers have the simplest design and lowest cost. The fixation of the moment of start of condensation is somewhat conditional. The temperature of the appearance of a noticeable plaque on the surface of the mirror and the temperature at which this plaque disappears are significantly different. In non-automatic hygrometers, the dew point is the arithmetic mean of these temperatures, which creates the possibility of subjective errors of the operator. In the simplest non-automatic hygrometers, easily evaporated liquids (ether, etc.) were used to cool the mirror. Evaporation rate decreases with decreasing temperature, and this method is unacceptable at low temperatures. In semiautomatic and automatic hygrometers, cooling mixtures, most often co-mixtures of solid carbon dioxide (dry ice) with gasoline or alcohol (temperature -78,6 ° C at atmospheric pressure), have been used. For deeper cooling, liquefied gases, such as nitrogen or liquid air (-194 ° C) are used [3].

Semiautomatic hygrometers allow very low dew point temperatures to be measured if a suitable cooler is selected. However, at temperatures below -80 ° C, the amount of gas required to reliably detect the condensate layer by eye is increasing; accordingly, the duration of single detection increases. Numerous designs of non-automatic and semi-automatic hygrometers of dew point are described in manuals for meteorological measurements.

Of greatest interest are the automatic hygrometers of the dew point. Devices of this type have much higher performance, but compared to non-automatic devices, and can operate in automatic systems. The automatic fixing of the dew point by the size (thickness, diameter) of the condensate layer is objective and allows to select the measurement moment correctly and to increase its accuracy [2].

The metrological and other technical characteristics of the automatic dew point hygrometer depend to a large extent on the method of cooling the mirror.

Modern devices of this type have thermoelectric cooling, a measuring circuit, a collection on static elements (magnetic semiconductors, etc.), and differ in high reliability, small size and weight.

The microwave method, which is to measure the natural gas humidity by the method of determining the dew point temperature under conditions of high vapor content of higher hydrocarbons, is promising. In the method of determining the temperature of the dew point on water in natural gas, based on the measurement of the temperature of the cooled mirror at the time of condensation on it of water vapor, radio waves of centimeter or millimeter ranges are used to control the condition of the surface of the mirror. The measuring cell of the hygrometer contains a dielectric waveguide cooled by a thermoelectric module and a surface temperature sensor for the waveguide. On one side of the waveguide is the source of microwave waves, on the other - the detector of these waves. As the waveguide cools below the dew point temperature, moisture droplets begin to condense on it, and the amplitude of the signal from the detector drops, which is captured by the electronic circuit, due to the absorption of the microwave radio-wave in water. The device practically does not react to the condensate film of higher hydrocarbons. This method allows to reduce the error of determining the temperature of the dew point in natural gas in the presence of vapors of higher hydrocarbons in comparison with the optical devices used for this purpose, several times [4].

Condensing optical hygrometers measure the temperature of the dew point in moisture quite well if, as the temperature of the mirror first drops, water condenses. However, if the gas contains vapors of propane, butane, pentane and other higher hydrocarbons, which have high condensation temperatures (and in real natural gas, as a rule, this is the situation), then the condensates of higher hydrocarbons will first fall out during the cooling of the mirror. .

In this case, determining the temperature of the dew point on the moisture will be made with a large error. This is due to the fact that the optical properties of higher hydrocarbons and water are close and to distinguish the beginning of the formation of a water film on a film of higher hydrocarbons (which at the same time increases in thickness due to the continuous condensation of higher hydrocarbons) is difficult and often impossible. Particularly difficult is the situation at underground gas storage stations, which are based on former gas-condensate fields. Even the latest condensing devices are extremely volatile there because of the high vapor content of the high hydrocarbons in the test gas [5].

Conclusion

The paper suggests the measurement of natural gas humidity using a microwave band and a cooled mirror of high-conductivity, transparent material. In this way, the accuracy of the measurement of natural gas humidity is increased by the method of determining the dew point temperature under conditions of high vapor content of higher hydrocarbons and gives an advantage over optical instruments for measuring humidity.

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Йосип Йосипович Білинський *– доктор техн.наук, проф., зав. кафедри ЕНС, Вінницький національний технічний університет, Вінниця; e-mail: yosyp.bilynsky@gmail.com*

Віталій Валерійович Красносельський *– аспірант кафедри ЕНС, Вінницький національний технічний університет, Вінниця, e-mail: wommerses@gmail.com*

Степанова Ірина Сергіївна *— кандидат філологічних наук, доцент, завідувач кафедри іноземних мов, Вінницький національний технічний університет, Вінниця, e-mail: Stepanova.fld@gmail.com*

Bilynsky Yosyp Y. — *Doctor of Technical Sciences, Prof., Head. Department of ENS, Vinnitsa National Technical University, Vinnytsia; Email: yosyp.bilynsky@gmail.com*

Vitalii Krasnosielskyi *– postgraduate the Chair of Electronics and Nanosystems, Vinnytsia National Technical University, Vinnytsia, e-mail: wommerses@gmail.com*

Iryna Stepanova *— Candidate of Philology, associate Profesor, Head of the Department of Foreign Languages, Vinnytsia National Technical University, e-mail: Stepanova.fld@gmail.com*