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Thermal Tubular Probe of Humidity of Disperse Granular Materials

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ABSTRACT:The paper reports the operational principle and the design of thermal tubular humidity converter of disperse granular materials in the process of heat exchange between the heated portion of the heat pipe and the flow of disperse material moving at constant flow rate and measurement of temperature difference prior to heating and at the heating section. Criterial equations for heat transfer during operation are given for moving disperse materials in round shaped pipes.
KEY WORDS: Humidity, Disperse Materials, Heat Converter, Heat Transfer, Thermal Conduction, Humidity Measurement, Heat Capacity, Temperature Difference, Thermal Resistive Element.

I.INTRODUCTION

In technological processes such as drying, humidification, enrichment and others, the knowledge of humidity parameters is of greater importance.

Amongst existing methods of monitoring of humidity parameters of granular disperse materials in continuous mode (capacitive method, conductometric, high-frequency and others) the thermal method proves to be the least developed and loosely studied one, even though the thermal method happens to be quite an effective one [1, 2, 3] for implementing continuous process control of humidity parameters of loose granular materials in the range from 0 to 15%.

Meanwhile, modern systems for monitoring and controlling humidity of disperse granular materials require that the humidity probes be multifunctional and ensure single configuration in a single casing for controlling humidity, temperature, the presence or absence of a flow of disperse granular materials. Thermal probes fit exactly into this pool of systems since the probes have often been equipped with heat-sensitive and heating elements that ensure simultaneous regulation of humidity content of disperse granular materials and their temperature.

II. SIGNIFICANCE OF THE SYSTEM

Thorough investigation and study of the operational principle and the design of thermal tubular humidity converter of disperse granular materials in the process of heat exchange between the heated portion of the heat pipe and the flow of disperse material moving at constant flow rate and measurement of temperature difference prior to heating and at the heating is particular interest especially in the course of design of effective humidity probes.The paper aims at investigating and optimizing the design of thermal tubular humidity converter of disperse granular materials.

III. LITERATURE SURVEY

C. Ling et al. report simulation of real particle shape in PFC numerical analysis, where the authors summarize four main methods. Calculation theory of PFC, as well as its basic command“Clump” was briefly introduced before the main steps of each method were outlined. Afterwards, the advantages and disadvantages of all the four methods were compared and discussed.

Andre Schellaet al. in their research paper Influence of humidity on the tribo-electric charging and segregation in shaken granular media study the effect of humidity on the charge accumulation of polymer spheres shakenvertically in a stainless steel container. The setup allows to control the humidity level from 5% to 100%RH while performing automated charge measurements in a faraday cup directly connected to the shaking container. Several mechanism suggested to explain tribo-electric charging involve water molecules attached to the surface.

G.S. Ghotooroet al. in their research devoted to field trials of cementitious backfill report that in general Type 1 Granular material is used for backfilling trenches in roads and footpaths. This material requires compaction. The authors report that the recent TRL study (Colwill,1999) on defects in reinstated trenches showedthat in 90% of the case compaction level was incorrect and in 50% compaction was insufficient. The authors state that further research is required to investigate the use of materials.

ArturWojcik et al. in their research devoted to the use of photogrammetric method for measurement of the repose angle of granular materials address a vitally important issue of precise determination of the angle of repose of granular materials. For calculation of the said angle, a photogrammetric 3D coordinate measurement method has been proposed. With the view of method verification, 600 independent measurement results were obtained.

Luis A. Pugnaloniet al. in their paper devoted to Multi-particle structures in non-sequentially reorganized hard sphere deposits examine extended structures., bridges and arches, in computer generated, non-sequentially-stabilized, hard sphere deposits.

IV. METHODOLOGY

Fig. 1 illustrates the design of a thermal tubular probe converter of humidity of granular disperse materials [3] which operates based on principle of heat exchange between the heated section of the heat conduit and the flow of granular disperse material moving at continuous rate as well as based on the measurement of temperature difference prior to heating and on heated section afterwards. Heat exchange in migrating flow of granular disperse material is characterized by heat transfer coefficient of the layer of disperse material α_c , which is determined by effective thermal conductivity coefficient of the layer λeff , by value of Nusselt criterion of the layer and diameter of the pipe d_{pipe}.

For performing calculation of heat exchange processes in tubular probe converters of humidity of disperse materials, criterial equations of heat exchange for moving disperse materials in circled tubes are recommended [4]. Meanwhile, all thermal physical properties of measured materials are determined by taking into account their dependence on humidity W of materials: heat conductivity $\lambda_{\text{eff}} = f_1(\text{w})$, heat capacity $C_{\text{p}} = f_2(\text{w})$, density $p = f_3(\text{w})$. In order to obtain static characteristics of a converter one needs to determine the temperature difference $T_1 - T_2 = f(w)$.

In the above mentioned design configuration of the humidity converter, the measured temperature difference $T_1 - T_2$ obtained by resistive thermometers 5 and 4 could be determined by formula on the basis of heath exchange process (1):

$$\Delta T = T_2 - T_1 = \frac{KP_{\text{нэ}}}{\alpha_c F}, \qquad (1)$$

where: $P_{нэ}$ – electrical power of the heating element; α_c – coefficient of heat transfer from the heated tube 2 to the flow of disperse material; F – area of heat exchange of tube 2; K – design-specific coefficient.

V. EXPERIMENTAL RESULTS

For experimental study of static characteristics, the authors have developed the design configuration of a tubular probe converter and sand was taken as disperse material for trial tests.

Disperse material in humidity probe converter (Figure 1) through the hopper sequentially passes through all three sections 1, 2 and 3 and is transported downstream in the form of flow with constant speed $V = 12 \cdot 10^{-2}$ m/sec through the ball feeder 7 equipped with electric drive. Tubes 1 and 3 are made of heat isolate material.

On the outer surface of the metal thin-walled tube 2, a heating element 6 is installed that is powered by a source of stabilized voltage. Inside the radial openings of pipe 1, semiconductor thermal resistors 4 connected in parallel were installed at a distance of 100 mm from the heating element 6, and above the heating element, thermal resistive elements 5 connected in parallel were installed along the perimeter which are connected to the adjacent arms of the bridge measuring circuit shown in Fig. 2.

Owing to the fact that the thermal resistors 4 are relatively far off from the heating element 6 and are in good thermal contact with disperse material, therefore they accurately measure temperature of the disperse material at the converter input. Thermal resistances 5 are installed at the heater section and measure the temperature of tube 2 with heater 6. Thermal resistances 4 and 5 are connected in parallel (Fig. 2) and are arranged around the pipe 2 equidistantly around the perimeter, which allows precise control of the average temperature of the disperse material and tube 2 with heating element in it.

As indicated above, resistance thermometers 4 provide information about input temperature of disperse material, while resistance thermometers 5 provide information about temperature at tube 2.

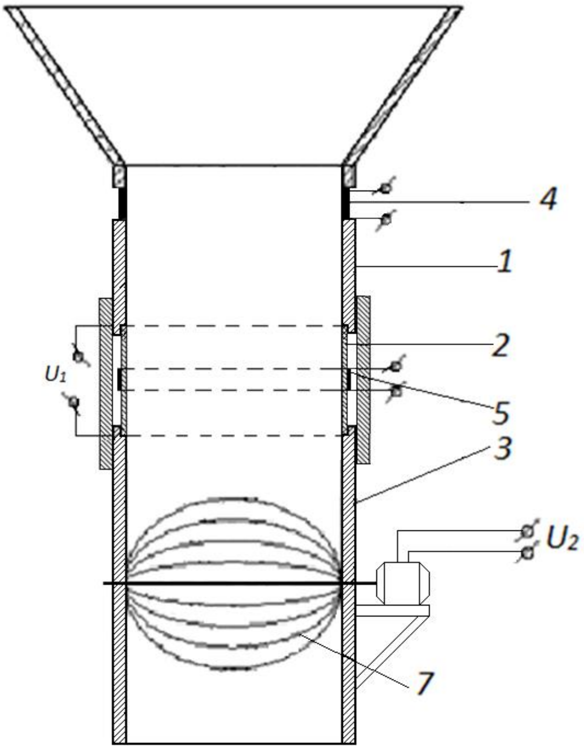

Fig. 1. Tubular humidity converter of disperse material:
1, 2 and 3 - sections of the converter pipeline, 4 and 5 - heat-sensitive elements, 6 - heating element, 7 - ball feeder, 8 – the converter casing

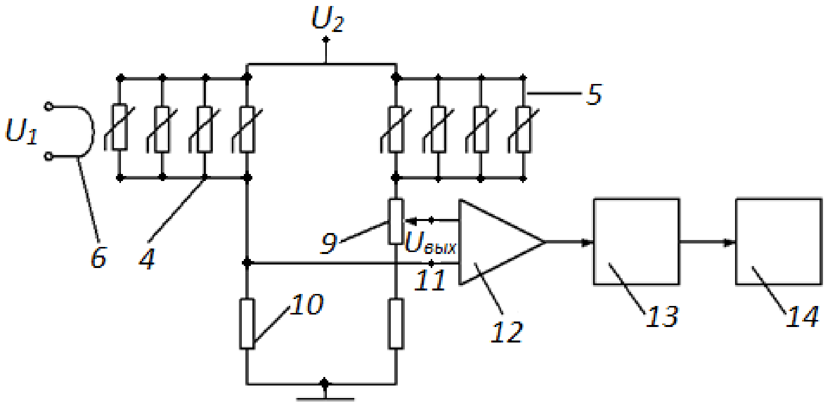

Fig. 2. Humidity converter bridge measurement circuit:

4 and 5 - semiconductor thermal resistive elements connected in parallel,
9, 10 – adjustable resistive element, 11 - constant resistive element,
12 - operational amplifier, 13 - analog-to-digital converter,
14 - the display of humidity measurement results.

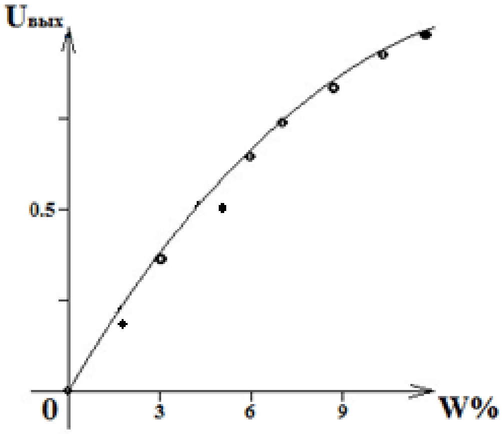

Fig. 3. Static characteristics of the humidity heat converter of disperse material:
line represents calculation; dots - experimental.

The central (middle) section 2 in the converter design as shown in Fig. 1. was made of copper pipe $d = 50$mm, the length of the heating element was 16 mm and the length of the section from the thermal resistance 4 to the heater 6 was 150 mm, the power of the heating element P = 20 Watt. To obtain the initial point of the static characteristic (Fig. 3), the trial sand sample was made to pass through the inlet hopper at initial humidity $W = 0$% while the heating element 6 and the ball feeder 7 were turned on and the bridge circuit was balanced using the adjusting resistive element 9 (Fig. 2) whereas $Uoutput = 0$ was maintained. Further, by feeding sand into the inlet of the hopper at various humidity values, a statistical characteristic $U_{\text{output}} = f(x)$ was obtained (Fig. 3), which allows controlling the sand humidity with an error of not more than $\Delta = 1{,}0$ %.

VI.CONCLUSION AND FUTURE WORK

The operational principle and the design of thermal tubular humidity converter of disperse granular materials in the process of heat exchange between the heated portion of the heat pipe and the flow of disperse material moving at constant flow rate and measurement of temperature difference prior to heating and at the heating section was examined.

On the basis of the designed disperse material humidity converter and by using operational amplifier 12 (Fig.2), an analogue-to-digital converter 13 and digital screen 14, the authors suggest that it could be possible to develop digital automatic humidity measurement units for various disperse materials.

REFERENCES

[1] Azimov R.K. Digital converters with distributed heat parameters. M., «Energiya», 1977.
[2] Obnovlenskiy P.A., Sokolov G.A. Thermal process control in chemical technology –L.: Chemistry, 1982. 174 pgs
[3] Azimov R.K., Abdurakhmanov A.A. Thermal humidity measurement unit of disperse granular materials. Patent № IAP 20150481, Bulletin, №6 (194)
[4] Gorbis Z.R., Heat exchange and hydromechanics of disperse flows. M. Energy, 1980.