Humidity measurement of loose materials

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Abstract: *In the paper, a new impulse method of humidity measurement of loose materials is described. The measurement stand and measurement principle are presented. A prototype automated equipment for humidity measurement of loose materials with the impulse method is described. Measurement results for two selected loose materials: copper ore concentrate and moulding sand are included.*

Keywords: humidity, measurement, moulding sand, copper ore concentrate

1. Introduction

Direct, analytical description of the process of real material deformation is an extremely complex and difficult issue. In practice, the models are applied that describe material structure and deformation mechanism in a simplified, approximated way.

Rheological properties of loose materials like soils, moulding sands etc, can be modelled by a viscoelastic model, as was demonstrated in [1].

Application of the above-mentioned model to describe rheological properties of a loose material (e.g. moulding sand) requires knowing the parameters that characterise its elastic and viscous properties, i.e. $k_C=f(\delta)$ and $k_T=f(\delta)$, where:
k_C -coefficient of elastic properties,
k_T-coefficient of viscous properties,
δ-material densening degree.

The relationships $k_C=f(\delta)$ and $k_T=f(\delta)$, e.g. for a moulding sand with bentonite Bentomak, are shown in Fig. 1. It can be found on the grounds of their analysis, that humidity of the moulding sand strongly affects its deformability and internal friction. Therefore, it can be said that humidity of the moulding sand is decisive for its compactibility during dynamic squeezing. The concerned relationship made a ground for developing a new impulse method of humidity measurement in disintegrated media.

2. Impulse method of humidity measurement [2,3]

Layout of the measuring stand is shown in Fig. 2a and its general view is shown in Fig. 2b. The stand consists of the following subassemblies:

- dynamic squeezing head (1),
- measuring sleeve (2),
- measuring line (3) for acceleration (C_2-W_2) of the squeezing foot and pressure (C_1-W_1) in return chamber of the squeezing head.

a) b)

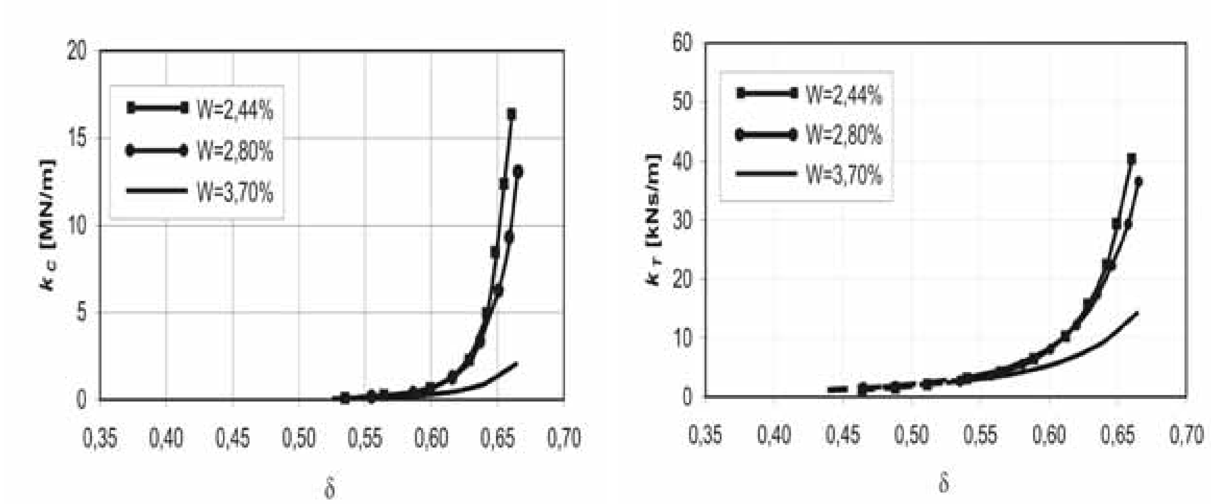

Fig. 1. Relationships $k_C=f(\delta)$ (a) and $k_T=f(\delta)$ (b) for moulding sand containing 6% of bentonite Bentomak, with various humidity

a) b)

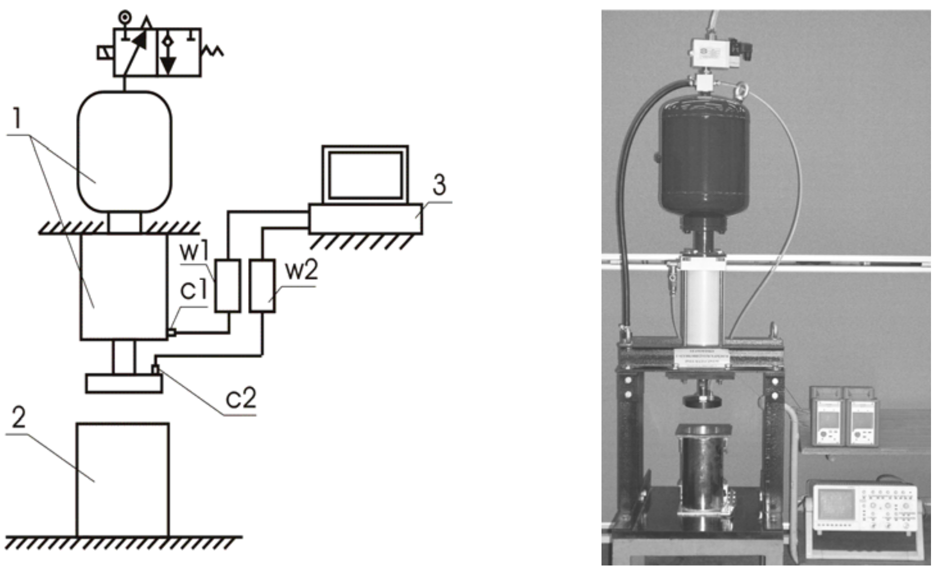

Fig. 2. Measuring stand for humidity measurements of loose materials with impulse method: layout (a) – dynamic squeezing head (1), measuring sleeve (2), measuring system (3) (C_1, C_2 – sensors; W_1, W_2 – charge amplifiers); general view (b)

Humidity measurement with the impulse method is composed of the following steps:

- dosing the material to the measuring sleeve,
- dynamic densening of the material with pressure *p* measurement in return chamber of the squeezing head,
- determining maximum pressure $p_{max} = f(W)$ that represents changes of maximum pressure in the return chamber of the squeezing head as a function of humidity. The reference characteristics $p_{max} = f(W)$ is valid for a specific material grade.

Humidity measurements with the impulse method can be performed automatically using the equipment [4] shown in Fig. 3.

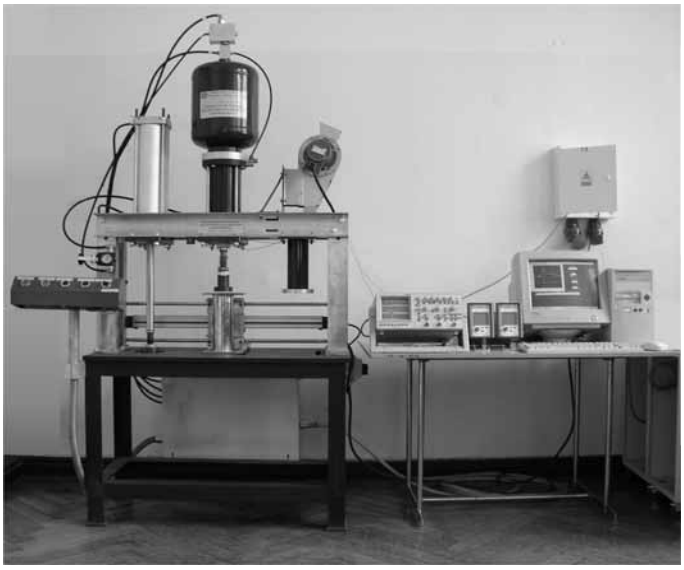

Fig. 3. Prototype automatic equipment for humidity measurement with impulse method

3. Experimental results

The relationship p_m = f(W) for the moulding sand with bentonite Bentomak is shown in Fig. 4. The presented relationship can be approximated with the polynomial

$$p_m=-0{,}208+0{,}805W-0{,}701W^{2}+0{,}266W^{3}-0{,}031W^{4} \quad (1)$$

that is valid in the humidity range W = 0.7 - 3,4 % H_20.

Figure 4 also shows the confidence interval limits calculated at the probability level 95 %. The maximum measuring error of humidity measurement for the moulding sand with bentonite Bentomak is ±0.15 % H_2O.

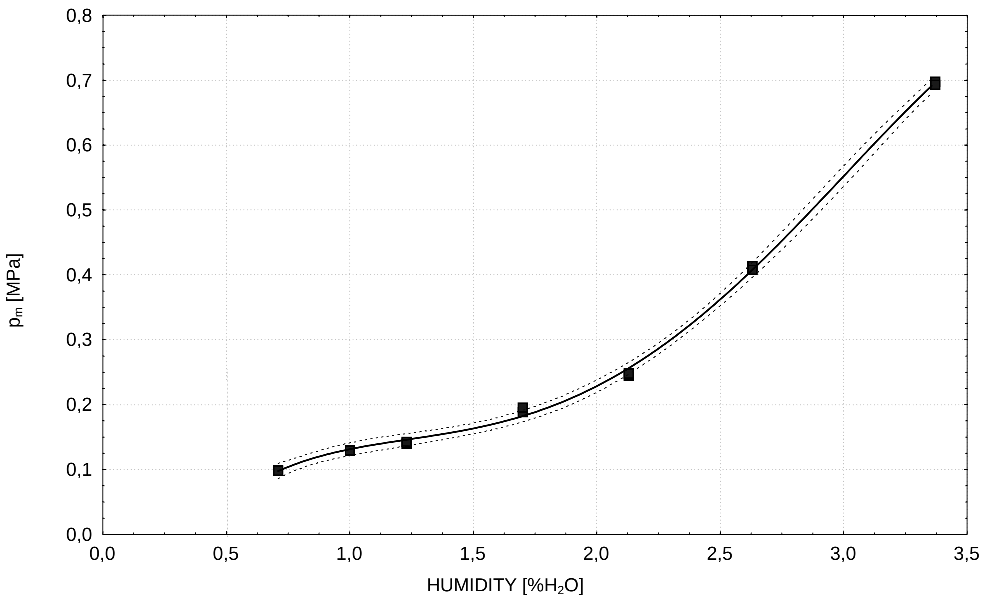

Fig. 4. Relationship p_m = f(W) for moulding sand with 6 % of bentonite Bentomak

Figure 5 shows the relationship p_m = f(W) for copper ore concentrate (25 % Cu) from copper mine Lubin. The presented relationship can be approximated with the polynomial

$$p_m=0,105-0,122W+0,064W^2-0,005W^3 \tag{2}$$

that is valid in the humidity range W = 0,5 - 8 % H_2O.

Figure 5 also shows the confidence interval limits calculated at the probability level 95 %. The maximum measuring error of humidity measurement for copper ore concentrate is ±0,3 % H_2O.

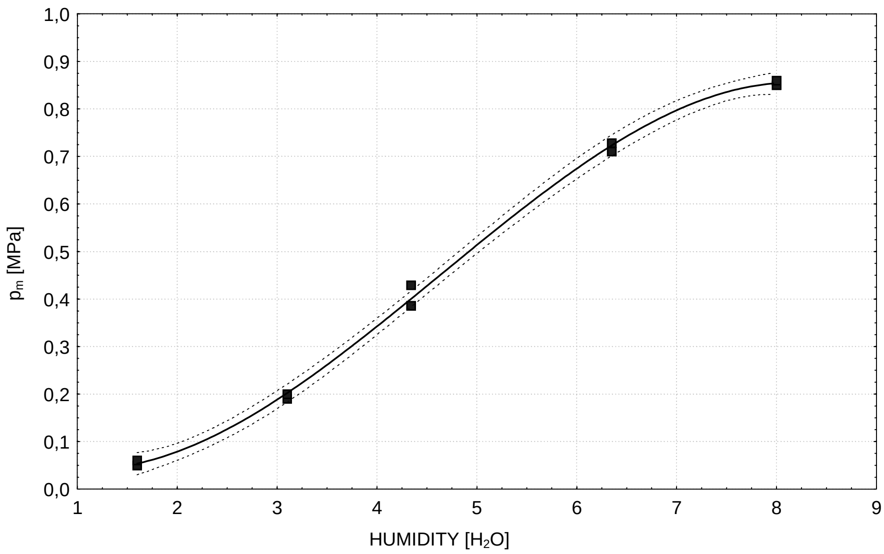

Fig. 5. Relationship p_m = f(W) for copper ore concentrate with 25 % Cu

4. Summary

A new method of humidity measurement of loose materials is presented in the article. The quoted experiments prove that humidity can be assessed using measurements of maximum pressure in the return chamber of the squeezing head during dynamic squeezing and humidity value for the specific material, taken from its reference characteristics p_{max} = f(W). The developed method of humidity measurement is characterised by very short measuring time (ca. 50 ms disregarding the sample preparation time) and by very high measuring accuracy. The presented results prove that the impulse method can be applied in industrial conditions for humidity measurements of various materials, including the materials for whose no sufficiently accurate and quick measuring method has been so far developed.

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