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THE EFFECT OF FOAM MULTIPLICATION FACTOR ON DENSITY AND STRENGTH OF FOAMGYPSUM

ВПЛИВ КРАТНОСТІ ПІНИ НА ГУСТИНУ ТА МІЦНІСТЬ ПІНОГІПСУ

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In the article, the conditions for foam production and its basic characteristics are considered The dependencies of determination of foamgypsum quality indeces on the foam ratio are obtained. This equations adequately describes the experimental points in the research. The construction of experimental samples of prisms from glued wood and placing of devices on them is shown. Thus, on the basis of experimental studies, the equations for predicting the strength of foam and the strength of foam-gypsum have been obtained. They can be used in the design of foam-gypsum composition.

В статті розглянуті умови отримання піни та основні її властивості. Отримані залежності для визначення показників якості піногіпсу від кратності піни. Проведено експериментальні дослідження і наведені отримані результати досліджень. Запропоновані рівняння адекватно описують наші експериментальні дані. Отримані результати показують, що підвищення міцності піногіпсу можливе за рахунок підвищення марки гіпсу. Метою подальших досліджень є визначення впливу інших властивостей піни на показники якості піногіпсу.

Keywords:
Foam, foamgypsum, multiplication, density, strength.
Піна, піногіпс, кратність, густина, міцність.

State a question. The conditions of foam obtaining and its main properties have been examined. The relations for the determination of foamgypsum quality indicators depending on the foam multiplicity have been obtained.

Foamgypsum is referred to as an effective building material. It has small density, low thermal conductivity and high fire resistance. The foamgypsum properties depend on the quality of its consitituents, namely, on bonding foams and additives.

Research methodology. During our research, the foamgypsum G- 5-B-II VS V.2.7 B-82-99, of the SPE Helios Production under the trademark "FEROZIT" have been used. As the surfactant, the foam solution was used, based on high molecular olefinsulfonat - Hostapur OSB produced by "EuroChem 1".

The aim of the research was to establish the influence of the multiplicity of foam on the density and the strength of foam-gypsum.

Foaming process due to the joint influence of physical, chemical and technological factors is rather difficult.

Foam depressiveness is substantially influenced by physical and chemical properties of the solution (surface tension, density, concentration of surfactant), the construction of technological apparatus, regimes of technological process forming the foam, as well as external factors (temperature, pressure, humidity, availability of dust) [1…3].

An important property of foam is its multiplicity (foaming possibility of the solution) - the amount of foam which is expressed in volume of foam, produced from the constant volume of solution, subject to certain conditions during certain period of time. The factors affecting the multiplicity of foam are the following: surfactant molecular structure, the concentration of surfactant, temperature, pH and the solution surface tension.

Foam has been obtained through dispargation that is mixing of solution foams and air. In technological aspect dispargation has been conducted using mixer at 3000 nozzle revolutions per minute of within 2 minutes. The plan of experiment and the foam quality parameters are listed in Table. 1.

In the experiment, the solution of dry substance surfactants of 25 ml volume has been used. Solution concentration changed from 0 to 0.42%, and density - from 1 to 1.00011, g/cm^3.

After dispargation, foam volume has been determined through experimental method and the volume of gas in it - as the difference between foam volume and the volume of solution:

$$V_{\text{gas}} = V_f - V_s \,. \qquad (1)$$

Foam multiplicity b characterizes the relative content of gas and liquid in the dispersed system:

$$\beta = V_f / V_s = (V_{\text{gas}} + V_s)/V_s \,, \qquad (2)$$

where V_f - the amount of foam, cm^3; V_s - the solution of surfactant, ml; V_{gas} - the volume of gas (air) in the foam, cm^3.

Taking into account equation (1) and (2), the amount of gas is determined by the equation:

$$V_{gas} = (\beta - 1)V_s \,. \tag{3}$$

Research results. Fig. 1 shows experimental values of foam multiplicity depending on concentration of surfactant solution. Basing on theoretical analysis of these data, the equation has been suggested:

$$\beta = 1 + A_{SUF}\sqrt{C_s(1 - C_s)}\,, \tag{4}$$

where A_{SUF} - coefficient, which is determined experimentally depending on the properties of surfactant solution; C_s - surfactant dry matter concentration in the solution,%.

Table 1

Experiment plan and foam quality characteristics

№	Water weight, g	Weight of SUF, g	Volume of SUF solution V_p, ml	Concentration of SUF solution C_p, %	Density of SUF solution ρ_p, g/cm^3	Foam volume $V_п$, cm^3	Gas volume $V_г$, cm^3	Foam multip-licity β	Foam density, $\rho_п$, h/m^3
1	25,000	0,000	25	0,00	1,00000	25	0	1	1,000
2	24,990	0,011	25	0,04	1,00001	281	256	11	0,085
3	24,979	0,021	25	0,08	1,00002	387	362	17	0,070
4	24,969	0,032	25	0,13	1,00003	468	443	19	0,051
5	24,958	0,042	25	0,17	1,00005	537	512	20	0,047
6	24,948	0,053	25	0,21	1,00006	597	572	24	0,044
7	24,937	0,063	25	0,25	1,00007	652	627	25	0,040
8	24,927	0,074	25	0,29	1,00008	702	677	28	0,035
9	24,916	0,084	25	0,34	1,00009	748	723	30	0,035
10	24,906	0,095	25	0,38	1,00010	792	767	32	0,031
11	24,895	0,105	25	0,42	1,00011	833	808	33	0,032

Foam density is defined as the ratio of foam mass to its volume:

$$\rho_f = (m_s + m_{gas})/V_f = (\rho_s V_s + \rho_{gas} V_{gas})/V_f = (\rho_s + (\beta - 1)\rho_{gas})/\beta\,, \tag{6}$$

where m_s, m_{gas} - weight of solution and gas correspondingly, g; ρ_{gas} - density of gas (air), ρ_{gas} = 0.00129 g/cm^3; ρ_s - solution density, g/cm^3.

The effect of foam multiplicity influence on its density is shown in Fig. 2.

During the formation of foamgypsum mass, it should be noted that the multiplicity of foam should be viewed not in relation to dual component systems (water + surfactants) but to multi-component systems (water + surfactants + gypsum).

In the actual industrial process, different types of additives (solidification retarders, superplasticizers, fiber, etc.) are being added to these basic components.

In the experiment, the foamgypsum mass has been got with the use of traditional technology [2].

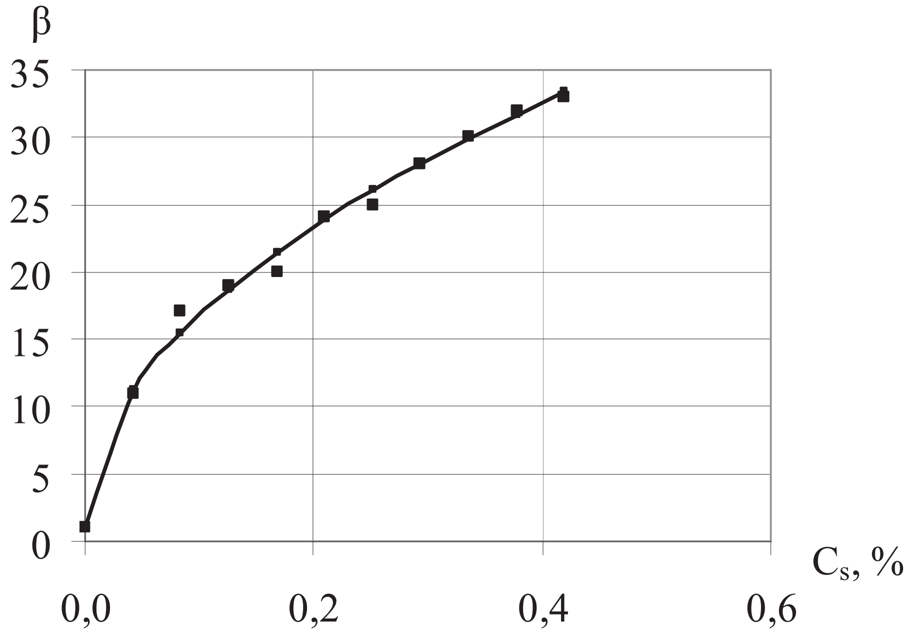

Figure.1. The dependence of foam multiplicity on concentration of surfactant solution

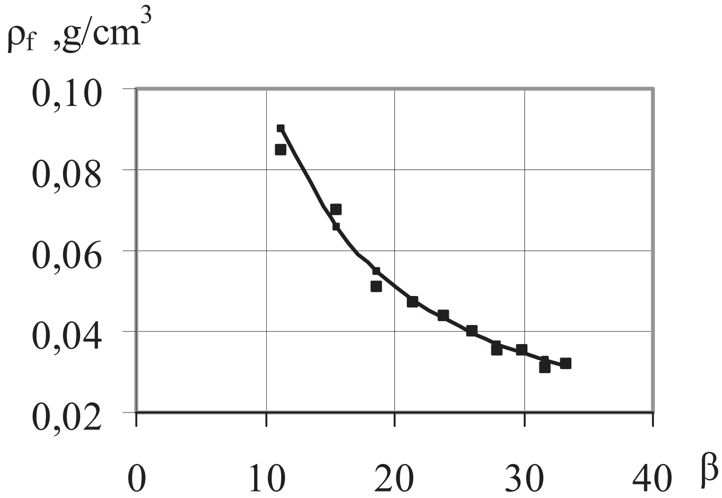

Figure.2. The influence of foam multiplicity on its density

Three series of experiments have been conducted with W/G equal to 0.55, 0.58 and 0.61. The mass of gypsum binder was constant. The volume of gas varied from 0 to 808 cm^3. The samples 10 × 10 × 10 cm have been formed of the foamgypsum mass.

After hardening and taking off the casing, the samples were subject to drying to the constant mass at the temperature of 55 ° C. Then their weight and strength have been determined.

When the foamgypsum mass is being generated, its volume depends on the volume of gypsum bonding, amount of water and gas. So, in the study of gypsum density it is important to introduce the complex factor, which takes into account the impact of each of these factors:

$$\frac{V_{gas}}{V_{gd}} = \frac{(\beta - 1)V_s}{\frac{G}{\rho_{gb}} + \frac{W/G}{G\rho_w}}, \quad (7)$$

where V_{gd} - the volume of gypsum paste; ρ_{gb} - the actual density of gypsum binder, ρ_{gb} = 2.65 g/cm^3; ρ_w - density of water. The results of determination of foamgypsum density ρ_{fg} depending on V_{gas}/V_{gd} factor are presented in Fig. 4. To determine the average foamgypsum density we have suggested the equation:

$$\rho_{fg} = \frac{\rho_g}{1 + A_V V_{gas}/V_{gd}} = \frac{\rho_g}{1 + A_V (\beta - 1)V_s/V_{gd}}, \quad (8)$$

where ρ_r - the true density of gypsum, ρ_r = 2.30 g/cm^3; A_V - the experiment coefficient, which takes into account the degree of gas reduction as a result of pressure of the mass of gypsum paste on it. If W/G = 0.55 - A_V = 0875, if W/G = 0.58 - A_V = 0762, if W/G = 0.61 - A_V = 0597.

This equation adequately describes the experimental points in the research. When V_{gas}/V_{gd} <0.3, as you see from Fig. 3, the water-gypsum ratio has a significant influence on the density of foamgypsum.

That is, with increasing of W/G the foamgypsum porosity increases and its density decreases. When V_{gas}/V_{gd} > 0.3, the volume of gas makes a significant impact on the foam gypsum density. But with the increase of W/G gypsum paste mass increases, which leads to the reduction in gas volume and increasing the foam gypsum density.

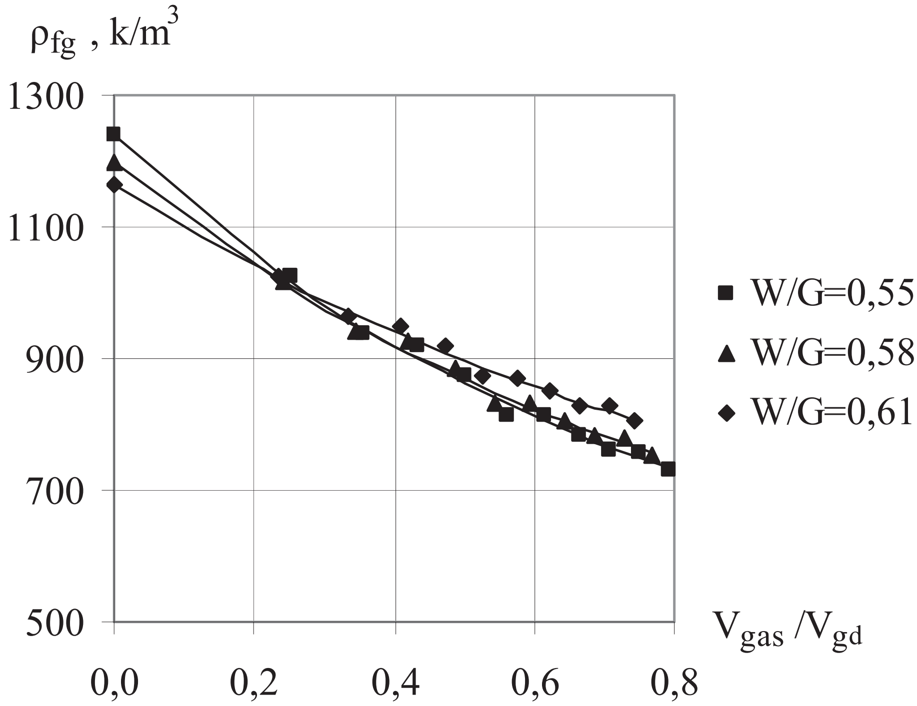

Figure. 3. Dependence of the average foamgypsum density on the ratio of plaster paste volume

The foamgypsum strength depends only on its density. Therefore, it is advisable to introduce factor ρ_{fg}/ρ_g , that is, ratio of average foam gypsum density to the true gypsum density, ρ_g = 2.3 g/cm^3. Fig. 4 shows the value of foamgypsum strength according to the authors and H. Bruncker data, depending on the $\rho_{fg}/(1000\rho_g)$ ratio.

The processing of experimental data has allowed to obtain an equation for predicting the foamgypsum strength according to the ρ_{fg}/ρ_g factor:

$$f_{pr} = K_{pr}(\rho_{fg}/(1000\rho_g)^{2,45}\ , \qquad (9)$$

where K_{pr} - the coefficient that corresponds to the strength of gypsum if the pores are suggested. The equation (9) adequately describes the authors' data when K_{pr} = 10.5 MPa and Bruncker's data when K_{pr} = 6.4 MPa.

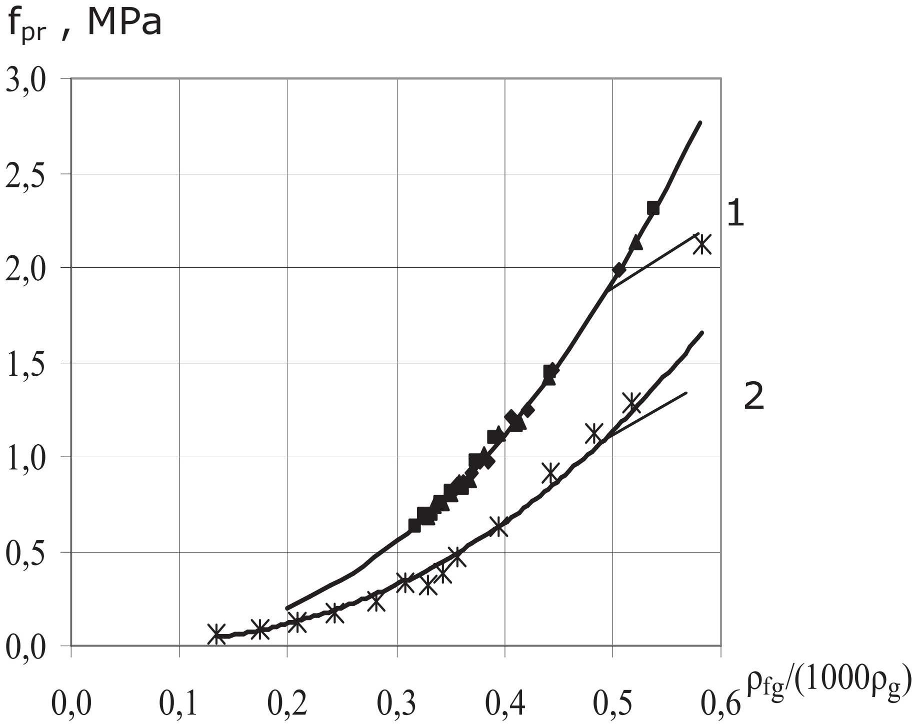

Figure. 4. Dependence of foamgypsum strength on the relation of foamgypsum density to the true density of gypsum:
1 – authors' data, 2 - H. Bruncker's data [3].

Conclusion. Thus, on the basis of experimental studies, the equations for predicting the strength of foam and the strength of foam-gypsum have been obtained. They can be used in the design of foam-gypsum composition.

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