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R. BUREK*, B. POŁEDNIK*, A. VERDIER**

THE INFLUENCE OF DOSAGE OF DIFFERENT TYPES OF FLOCCULANTS ON THE DENSITY OF CAKE

The content of solid matter in the cake depends upon the type of the flocculant and its dosage. The increase in dosage reduces the content of solid matter in cake, but this dependence is not monotonic. All results show a decrease of solid matter content as dosage increases, followed by a minimum, and, finally, a rise to a somewhat constant value. The effect is greater for nonionic than for ionic flocculants.

1. INTRODUCTION

Cake is the deposit formed by settled flocs. It is known that the size and density of the flocs influence the settling velocity. These parameters depend on the dosage of flocculants [1], [2].

In the present paper we are going to answer the following questions:

1. What is the density (concentration of solid matter) of the cake?

2. In what extend do the dosage and the type of flocculant result in the density of the cake?

2. DETERMINATION OF THE CONTENT OF SOLID MATTER IN THE CAKE

Observations indicate that the cake is a condensed slurry contrary to the deposit obtained without flocculants, which consists of a homogeneous layer of the settled solid phase. The average density of the cake can be roughly determined by its volume if the amount of solid matter in the suspension is known. If not, it has to be measured.

* Wydział Zarządzania i Podstaw Techniki, Zakład Fizyki, Politechnika Lubelska, ul. Nadbystrzycka 38 d, 20–618 Lublin, Poland.

** Ecole Nationale Supérieure de Chimie, 118 Route de Narbonne, 31077 Toulouse Cedex, France.

The intensity of transmitted or backward-scattered X and β radiation depends on both concentration and size of solid phase particles in water. The backward scattered intensity is given by [4]:

$$I(d, \alpha) = (I_1 - I_2)\left(\varphi_1 + \frac{2\varphi_1 - 1 - \varphi_1(e^{\mu_1 x} + e^{\mu_2 x}) + e^{\mu_1 x}}{e^{\mu_1 x}\, e^{\mu_2 y}} + I_2\right),$$

$$\varphi_1 = \frac{1}{1 + \left(\frac{1-\alpha}{\alpha}\right)^{1/3} \frac{\varrho_1}{\varrho_2}}, \qquad y = \left(\frac{1-\alpha}{\alpha}\right)^{1/3} x$$

where:

I_1, I_2 – the intensities of backscattered radiation of phases 1 (solid material) and 2 (water), respectively,

ϱ_1, ϱ_2 – densities of phases 1 and 2, respectively,

α – concentration of the solid matter,

μ_1, μ_2 – mass absorption coefficients of phases 1 and 2, respectively,

x, y – mass per unit area of phases 1 and 2, respectively.

A measuring device comprising a 90Sr + 90Y beta source, a scintillation counter, and the appropriate electronic device is shown in fig. 1. The sample is put in a vessel

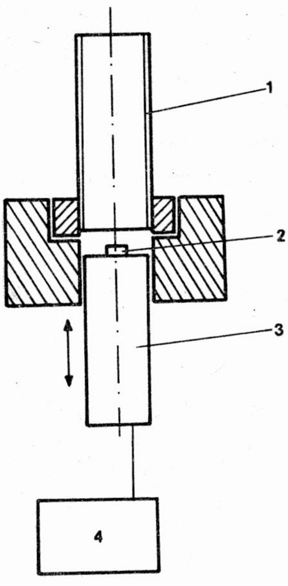

Fig. 1. Scheme of the experimental device

1 – presentation vessel, *2* – detector, *3* – source of β radiation, *4* – electronic device

(60 mm diameter, 200 mm height) containing 500 cm^3 of the slurry. The bottom of the vessel is made of 0.3 mm thick polypropylen. The gauge has been calibrated experimentally.

3. EXPERIMENTAL

3.1. MATERIAL

A colloidal suspension was prepared by dispersion of selected bentonite [3]. The size of grains ranged within 0–60 μm, and their density is equal to 2.41 g/cm^3. Cationic, anionic, and nonionic flocculants have been used.

3.2. FLOCCULATION EXPERIMENTS

The flocculation experiments were carried out in the presentation vessel (fig. 1). The suspension preparation comprised the following steps: 1 min mixing at 150 rpm, 5 min flocculation at 60 rpm, and 15 min settling. The dose of the flocculants was changed in the range 1–180 g/m^3. The suspensions contain 3, 10, and 40 g of solid matter per 1 dm^3 of water.

4. RESULTS

The content of the solid phase in the cake is affected by the properties of the flocculant, its dosage, and the content of the solid phase in the suspension.

In general, the concentration of the solid substance as a function of the amount of flocculation agents cannot be simply described.

All results show the typical decrease of α as the dosage increases, which is followed by a minimum value of α and, finally, there is observed a rise of α to a somewhat constant value.

From fig. 2 it is seen that if ionic and nonionic agents are applied, the concentration has a broad flat minimum, whereas for cationic agents the minimum is sharp.

The dosages of the anionic and nonionic agents at which the concentration reaches its minimum are the same, while for the cationic ones they are smaller.

The concentrations of the solid phase in the cake due to the applied agents are different; since other properties of the agents (e.g., the molecular weight) are not known, further assertion cannot be made.

The influence of the content of the solid phase in the slurry on its concentration in the cake is shown in fig. 3. Three doses (3, 10, and 40 g/dm^3) of bentonite and a nonionic flocculants have been applied. Both the solid phase content in the cake and the dosage at α_{min} increase with the solid phase concentration in the slurry.

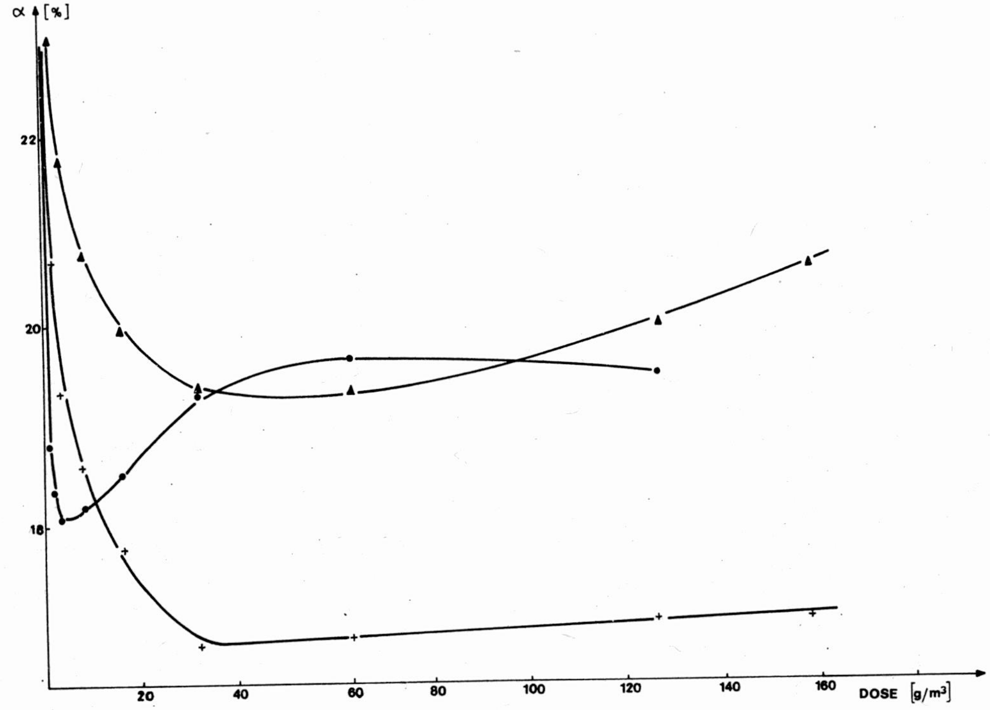

Fig. 2. Dependence of the content of the solid phase in the cake on dosages of nonionic (+), cationic (·), and anionic (▲) flocculants

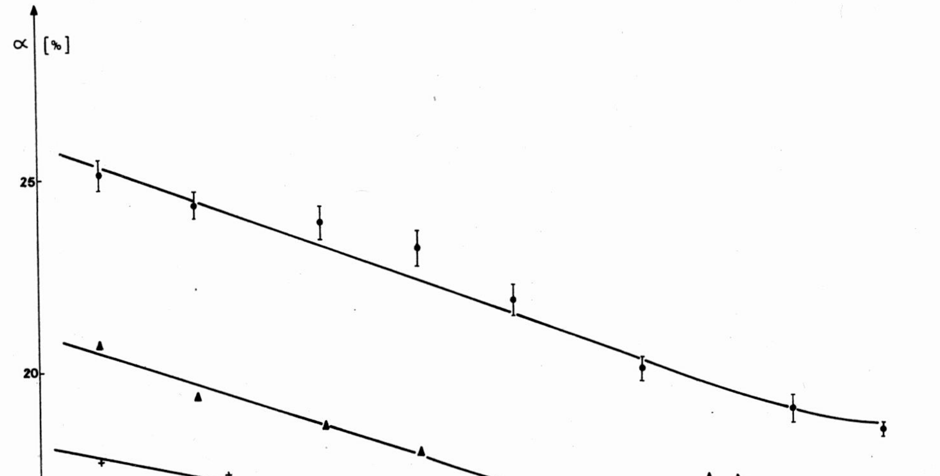

Fig. 3. Dependence of the content of the solid phase on dosage of a nonionic flocculant for slurries containing 3 (+), 10 (▲), and 40 (·) g/dm^3 of solid substances

5. DISCUSSION

5.1. DESTABILIZATION EFFICIENCY

Optimum dosage of flocculant is achieved when the destabilization efficiency of the suspension reaches its maximum. This is indicated by the settling velocity, residual amounts of bentonite, electrophoretical mobility, and others.

The experimental results (figs. 2, 3) imply that the content of the solid phase in the cake can be used for determination of the optimum dosage. As can be seen from fig. 4 the intensity of the backward scattered radiation, and thus α as well are correlated with the size of the flocs.

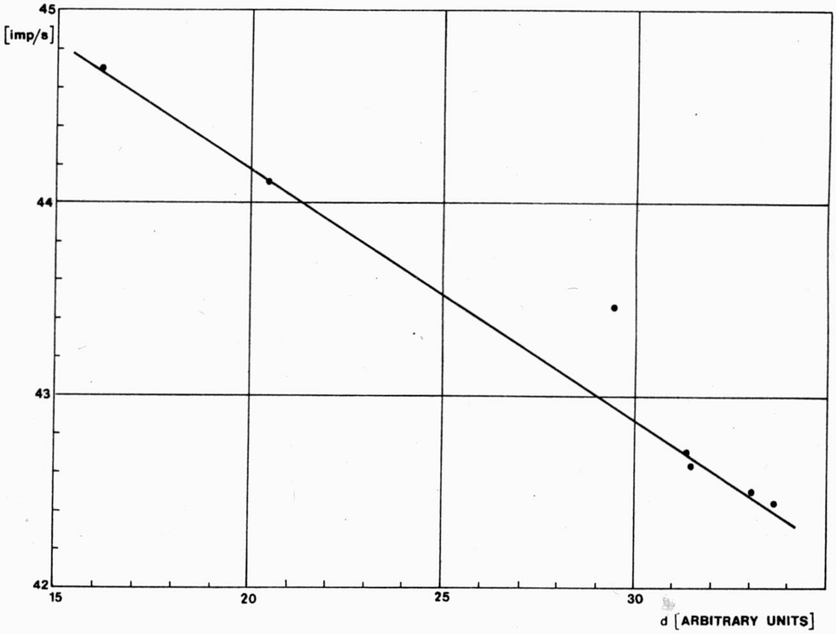

Fig. 4. Dependence of backscattered intensity on the size of the flocs

The settling velocity depends on the floc size (fig. 5). The influence of the flocculant doses on the floc sizes is demonstrated in fig. 6. A comparison of figs. 2 and 6 shows that the dosages of cationic agents at which the average size reaches its maximum and α its minimum are almost the same. In the case of anionic and nonionic flocculants the optimum dosages differ.

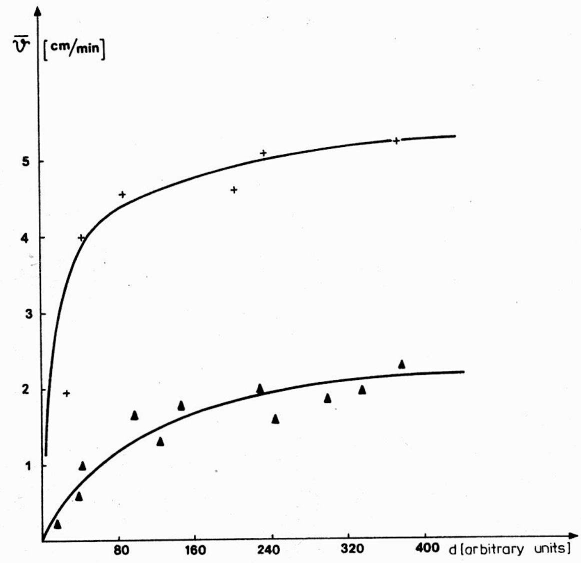

Fig. 5. Dependence of settling velocity on the size of the flocs due to nonionic (+) and anionic flocculants (▲)

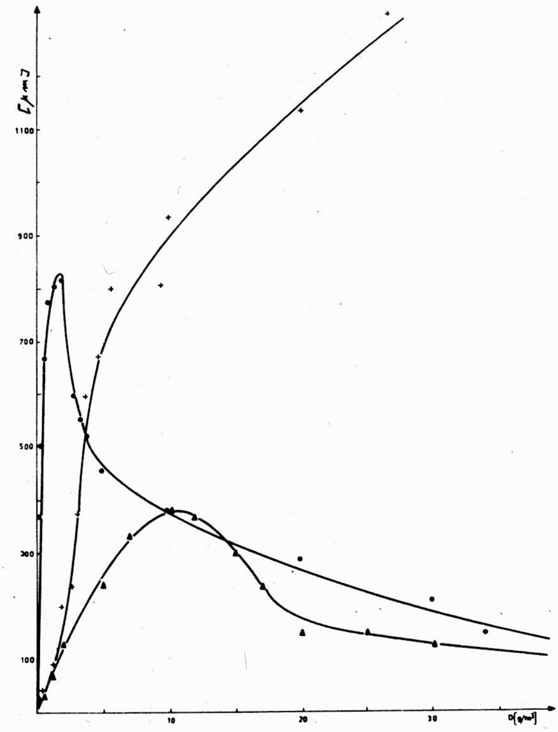

Fig. 6. Dependence of floc size on the dosages of cationic (·), anionic (▲), and nonionic flocculants (+)

5.2. FLOC FORMATION

The bentonite doses of 3, 10, and 40 g/dm^3 correspond to 0.289%, 0.994%, and 3.91% solid phase contents in the slurry. The content of solid matter in the cake usually changes from 18 to 25% at low flocculant dosage (1.20 g/m^3), and from 16 to 18.8% at its high dosage. From those measurements it follows that the increase of solid material in the slurry by a factor of 13 causes an increase of α in cake by the factors of 1.42 and 1.1847 at the low and the high dosage, respectively.

The results indicate that independtly of the amount of solid matter in the slurry the amount of grains fixed at the polyelectrolyte is roughly constant. Thus, we can suppose that the growing of floc takes place when the floc settles down. The observations agree with the theory which proves the statement that the number of fixed grains increases with the velocity of the flocs.

5.3. FINAL REMARKS

The concentration of solid matter in the cake is related to the size and density of the flocs. Optimal settling conditions are contrary to the conditions for creating the best cake.

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WPŁYW DAWKI RÓŻNYCH TYPÓW FLOKULANTÓW NA GĘSTOŚĆ OSADU

Zawartość substancji stałych w osadzie zależy od typu i dawki flokulanta. Ze wzrostem dawki flokulanta zmniejsza się zawartość substancji stałych w osadzie, jednakże zależność ta nie jest monotoniczna. Wszystkie otrzymane wyniki wykazują, że gdy dawka flokulanta zostaje zwiększona, zawartość substancji stałych maleje, po czym osiąga wartość minimalną, a następnie wzrasta do pewnej wartości stałej. Efekt ten jest większy w przypadku niejonowych flokulantów.

ВЛИЯНИЕ ДОЗЫ РАЗНЫХ ТИПОВ ФЛОКУЛЯНТОВ НА ПЛОТНОСТЬ ОСАДКА

Содержание твердых веществ в осадке зависит от типа и дозы флокулянта. Вместе с повышением дозы флокулянта понижается содержание твердых веществ в осадке, однако эта зависимость не монотонична. Все полученные результаты обнаруживают, что когда доза флокулянта повышается, содержание твердых веществ понижается, после чего достигает минимального значения, а затем ростет до некоторого постоянного значения. Этот эффект больше в случае неионных флокулянтов.