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THE VARIOUS INFLUENCE OF CHANGES OF THE SUSPENSIONS CONCENTRATION ON THE PROCESS OF THEIR SEDIMENTATION

A research of the grain constitution of the polidyspersant suspension as a function of its concentration is presented. Both the theoretical deliberation and the laboratory research have confirmed, that – at a certain range of concentration – an increase of the particles' settling velocity occurs, which is raising the sedimentation efficiency. That increase may even decrease the particles' concentration in the cleared suspension in spite of the increase of the concentration of the solid phase particles in the suspension being cleared.

Introduction. One of the crucial problems one has to do, while investigating the settling of polydyspersant suspensions is the correct evaluation of the particles' settling velocity in the solid phase of the suspension as well as the analysis of the influence of the concentration changing on the settling velocity.

There is no doubt, that the particles' concentration in the solid phase substantially involves the settling velocity of them. This fact is described in many books and publications of chemical and process engineering, sanitary engineering, mineral stuff processing. However in some cases in the subject bibliography we come across (very often antagonistic) ideas regarding the phenomenon of the mentioned influence.

The most popular opinion presented in the literature says, the particles' concentration in the solid phase causes a decrease of their settling velocity. It is explained through the fact, that any increase of the suspension concentration raises the reciprocal constraint of the particles' settling velocity in the solid phase, which must lead to the decrease of their settling velocity.

In order do describe this quantitative increase, the Stoke's formula is corrected through replacing liquid phase viscosity of the suspension by the relative viscosity ψ, which is the quotient of the suspension viscosity at the given particles' concentration in the solid phase φ and the pure liquid phase viscosity (at the suspension concentration equal 0).

$$\psi(\varphi) = \frac{\mu(\varphi)}{\mu_0} \tag{1}$$

In the bibliography there are many formulations presenting the relationship between the relative viscosity and the particles' concentration in the solid phase. The most often used formulas are presented below:

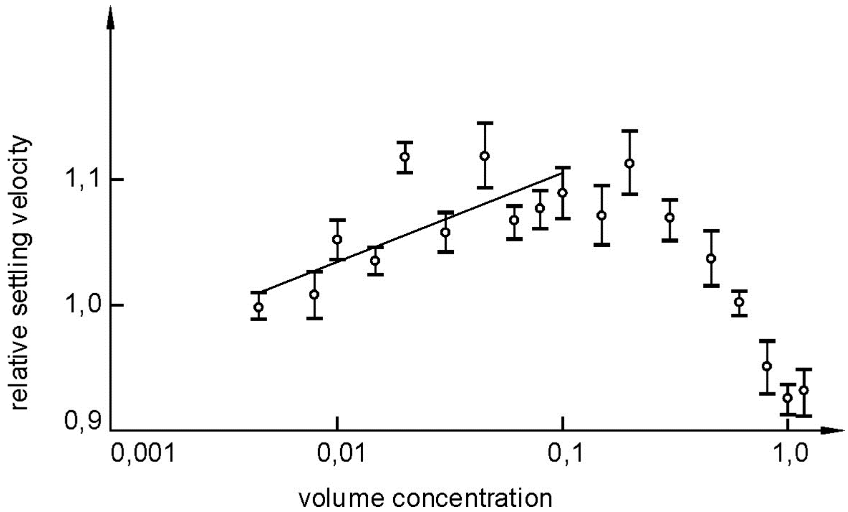
Einstein's equation:

$$\psi(\varphi) = 1 + 2{,}5\,\varphi \tag{2}$$

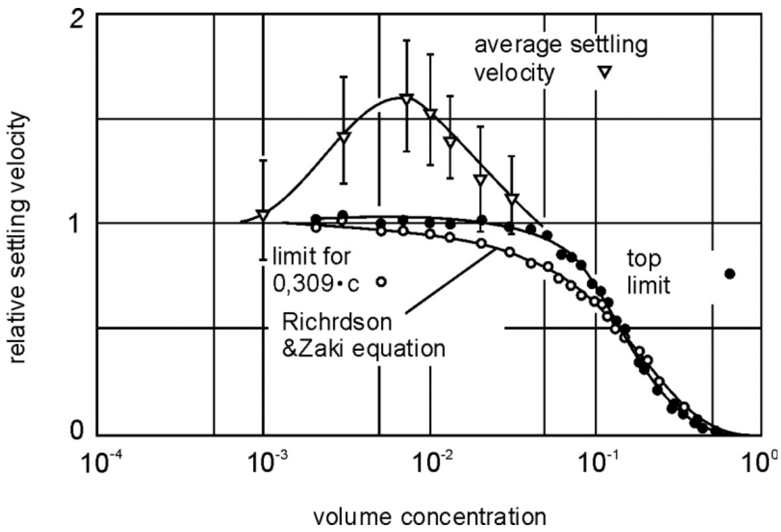
Kunitz's equation

$$\psi(\varphi) = \frac{1 + 0{,}5 \cdot \varphi}{(1-\varphi)^4} \tag{3}$$

Another researcher also elaborated a number of formulas showing in the similar way the rela tionship between suspension viscosity and its concentration. Several relationships of this type were presented by Gambill [1].



a)



b)

Fig. 1. The relative settling velocity of the particles in the solid phase suspension according to a) Barfod, b) Binder/Wiesmann

The correction of the Stoke's formula by introducing of the relative viscosity leads to the results, which always demonstrate one dependency – each increase of concentration decreases the settling velocity of the grains.

A different relationship between the suspension concentration in the solid phase and the settling velocity was showed in the articles by Barford [2] and Binder/Wiesmann [3].

Laboratory Research. In order to estimate the consequences of the concentration variation of the typical industrial suspensions in the solid phase a laboratory research – sedimentations of the suspensions – was conducted.

Typical industrial suspensions – coming from converter-oxygen steel plant, from blast furnace gas refinery, from sinter plant as well as the chrome and coaly suspensions were used as the research material.

All these suspensions differ vitally from one another by solid phase density and the granulometric constitution – depending on the origin of the particular suspension.

Research methodology. The particles' graining in the solid phase of the suspension may be investigated by different devices. However for the purpose of using research's results in the settling processes' calculations the preferred method of investigation is the use of the sedimentation balance. There are two main reasons for using this device – first the real sedimentation process is showed during the measure of small scale and secondly – the mathematical description of the relationship between the substance put on the balance scale and the time as well as the mathematical descriptions of the relationships between the sedimentation efficiency and the surface load can easily be special cases of the same, common mathematical model. In the research conducted there were not any dispersion agents used in order not to lose any information about the particles' behaviour in the sedimentation process (e.g. gluing one to another). The gained research results were in the form of the parameters' values of the solid phase particles sizes statistic distribution showed in the dependency on the suspension concentration. A logarithmic normal distribution was chosen for the grain sizes distribution, because it describes in a good way the granulometric constitution of the industrial suspensions. coming from the granulating processes (Theorem of Kolmogorov) and it offers the possibility of the comparison the gained results with results of another research.

The research of the distribution of the particles' sizes in the suspension solid phase was conducted by the sedimentation balance Mettler Toledo. A detailed description of the research stand and of the results interpretation method was published in the articles [5-6].

The research of the particles' graining in the suspension solid phase has been done by subsequent concentration changing – that means the suspension was successively diluted, most often in the ratio 1: 0,75.

The initial highest suspension concentration was comparable with the concentration of the suspension, which was taken as a sample. After completion of each measure the weight of the settled particles on the balance scale an well as the suspension volume were known. On the basis of the gained data the real suspension concentration was calculated.

Results. We got as the results the parameters' values of the logarithmic normal distribution of the particles' sizes in the solid phase of the given suspension. The gained discrete relationship between the parameters' values and the concentration was approximated by means of the exponential function. There were obtained following dependencies of the grain constitution's parameters on the suspension concentration (4). The independent variable was the concentration of the suspension s.

$$m = b \cdot e^{a \cdot s} \qquad \sigma = b \cdot e^{a \cdot s} \tag{4}$$

On the basis of such determined parameters' values of the grain constitution there was an sedimentation efficiency calculated for the a priori assumed surface loading q = 1 m/h. The calculated sedimentation efficiency allowed to determine the final concentration.

The measures and calculations results are showed in the form of the charts showing following dependencies:

a) grain constitution: the average value (fig. 2) and the standard deviation (fig. 3)
b) sedimentation efficiency (fig. 4)
c) final suspension concentration (fig. 5)
as the function of the suspension concentration.

Because of limited place in that article there were only the measures and calculations results of the suspension produced by converter-oxygen steel plant. The research results for all the outstanding – metallurgical, coaly and chrome suspensions are presenting quite similar tendency of the dependency of the granulometric constitutions' parameters. That means they also present a similar sedimentation efficiency as well as the final concentration after the sedimentation process showed as a function of the initial suspension concentration.

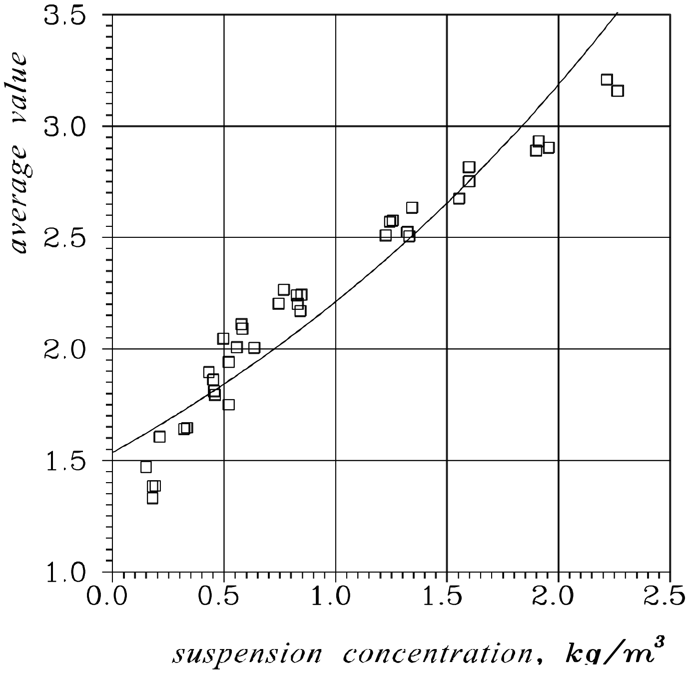


Fig. 2. The average value of the logarithmic normal distribution as the function of suspension concentration

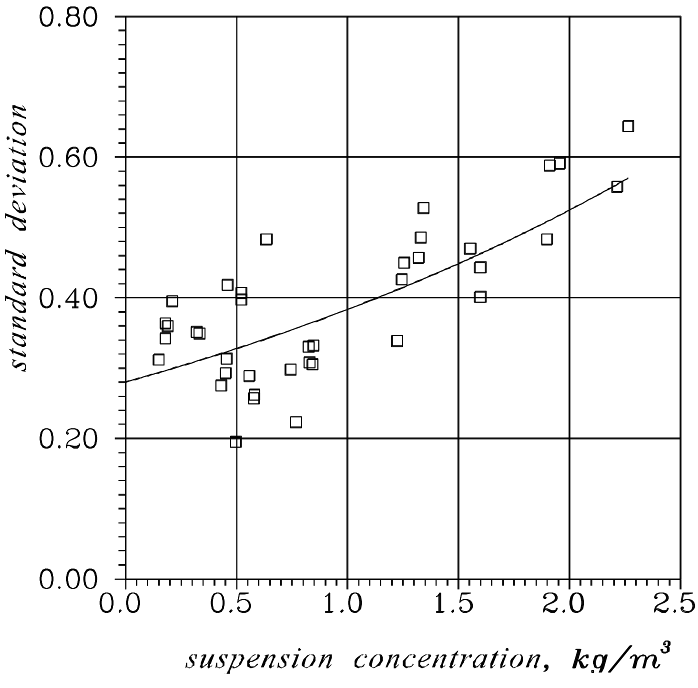


Fig. 3. The standard deviation in the logarithmic normal distribution as the function of suspension concentration

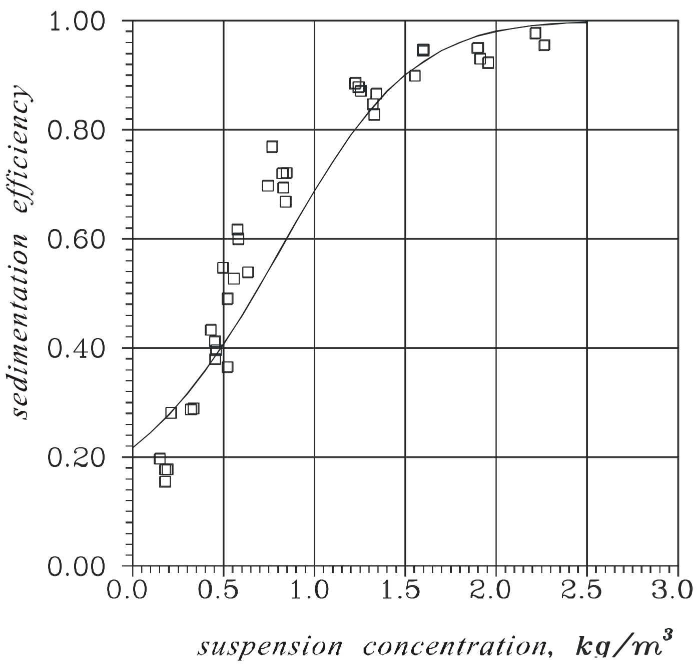


Fig. 4. The sedimentation efficiency as the function of suspension concentration

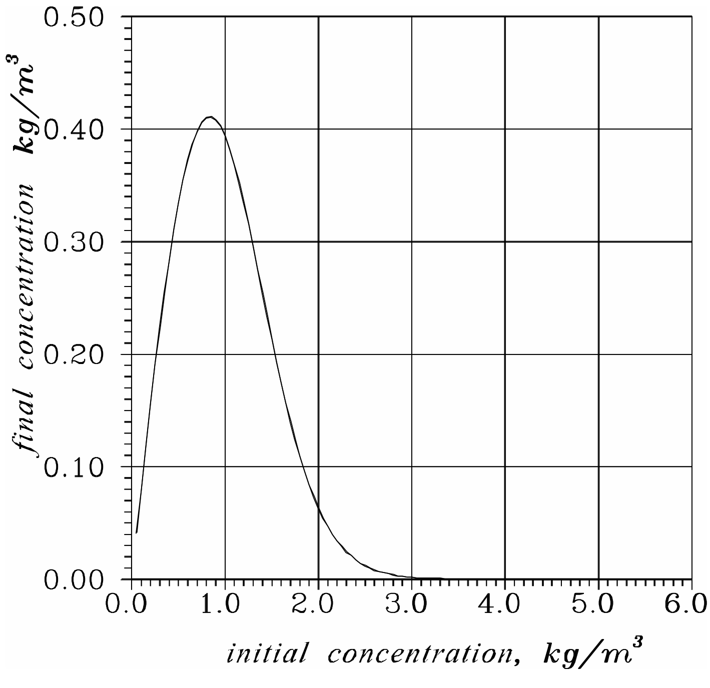


Fig. 5. The concentration after the process as the function of the initial concentration

Conclusion.

– The research of the parameters' values of the grain sizes distribution and on that basis calculated sedimentation efficiency and the final concentration in the clear water have confirmed the influence of the suspension concentration on the sedimentation efficiency presented in the articles by Barford, Binder/Wiesmannn, Pienkowska/Herczynski. At the lower levels of concentrations the increase of the concentration may raise the settling velocity of the solid phase particles or even decrease of the final suspension concentration.

– The presented effects occur within all investigated – metallurgical, coal and chrome suspensions.

– The calculation results lead to the conclusion, that in the diluted suspensions – at a certain range of concentration – an increase of the particles' settling velocity occurs, which is raising the sedimentation efficiency. That increase may even decrease the particles' concentration in the cleared suspension in spite of the increase of the concentration of the solid phase particles in the suspension being cleared.

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