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THE HYDRODINAMIC OF THREE-PHASE FLUIDIZED BED WITH LOW DENSITY SOLIDS

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ABSTRACT. In this paper are presented the experimental data concerned minimum fluidization velocity and pressure fall in fluidized bed with low density solids (ρ=179 ÷ 312 kg/m^3) and high diameter (d=19 ÷ 38 mm) with pellicular two and three-phases flow of fluid on fluidized solid surface.

New relations are propoused for minimum fluidization velocity and pressure fall determination on base of obtained experimental data.

Minimum fluidization velocity has been corelate with solid specific features and sprinkling density form which column is getting drown.

Low pressure falling and fluidization velocity (2 ÷ 5 m/s) gives the utilization possibility of three-phases fluidized bed, with small density solids, in purification of high fluid debits through absorption and chemosorption processes in low dimension and compact instalation unit.

Introduction

The depollution of gas emanations represents one of the most fundamental problems of humanity. Through industrial activities in many times, big volumes of gas who contain noxes are ousted in atmosphere. This emanation have an important impact on environment. The quantities of noxes, in continous development, had imposed the elaboration of new tehnologies for purification of gas emanations before remission in atmosphere.

The essential characteristics of those emanations are higher debits of gas and small concentrations of noxes in the gas mass. This determine a lower efficienty of gas purification proccess.

The classic methods as absorbtion in columns, sparkling beds and pulverisation has been inefficient because of higher power consuption (big drop pressure) and small rates of mass transfer. All this determine the necessity of big dimentions for industrial units. Also cannot be neglected the drowned phenomenon in packed towers then when gas debit excel a certain value.

Those are the resons who had determine the conception of new methods of phase contact in gas-liqiud system.

This paper has the role to drow up a new method of phase contact in gas-liqiud system. This method is three phase fluidised bed. In this method is much lessened the drowned phenomenon of column simullation with achivement of higher coefficient of transfer.

The use of fluidized bed in chemosorbtion proccess is limitated by big drop pressure because of high density particules, even at small hights of beds. This was the reason who lead to attempts of use of certain beds particles with $d_p>10^{-2}$ m and small densities.

Because specialty literature contain a few dates for hydrodynamics of three-phase fluidized beds, for filling corps with big dimentions (d_p>10^{-2}-$7\cdot10^{-2}$) and low density (50-350 kg/m^3), this study have the purpose to determine the hydrodynamics in this new conditions.

In specialty literature [1,3,4,5,6,7] are suggested many ecuations for establish minimum fluidization velocity. Critical analysis of those ecuations with a view to applying for this new conditions (d_p ↑, ρ_p ↓) had showned that this cannot be used (table 1).

Comparing the obtained experimental results with those determined by specialty literature ecuations porpoused, it's fending out that in all cases there are big difference. In all cases minimum fluidization velocity, determined experimental, is much smaller than that determined with existing ecuations. Result the elaboration necessity of new relations as for two-phase fluidization as three-phase in conditions when liqiud flowing on bed surfaces is filming and fluidized bed isn't drowned.

Table 1.

Analysis of speciality literarure ecuations for minimum fluidization velocity.

Ecuation	Type of filling				
	d_p=0,01m ρ_p=337,5kg/m^3 ε_0=0,45	d_p=0,0194m ρ_p=312kg/m^3 ε_0=0,33	d_p=0,0191m ρ_p=210kg/m^3 ε_0=0,33	d_p=0,038m ρ_p=94 kg/m^3 ε_0=0,30	d_p=0,074m ρ_p=48 kg/m^3 ε_0=0,50
1. **Lewa** $w = 9{,}35\cdot10^{-3}\cdot\frac{d_p^{1{,}8824}}{\nu_f^{0.8824}}\cdot\left(\frac{\rho_p-\rho_f}{\rho_f}\right)^{0{,}9421}$	5,81	18,8	12,55	21,36	39,28
2. **Levis** $w = \frac{1}{200}\cdot\frac{\varepsilon_0^3}{1-\varepsilon_0}\cdot\varphi^2\cdot\frac{d_p^2\cdot\rho_p\cdot g}{\eta_f}$	15,23	17,16	11,19	14,26	179,06
3. **Rowe** $w = 0{,}00081\cdot(\rho_p-\rho_f)\cdot\frac{g\cdot d_p^2}{\eta}$	14,84	51,62	33,61	59,09	112,9
4. **Gupalo** $\mathrm{Re} = \frac{Ar\cdot\varepsilon_0^{4,75}}{18-10{,}6\cdot\sqrt{Ar\cdot\varepsilon_0^{4,75}}}$; $\mathrm{Re} = \frac{w\cdot d_p\cdot\rho_f}{\eta_f}$.	25,15	19,08	12,42	13,77	324,64
5. **Experimental results**	2,44	2,45	2,44	3,15	2,99

Experimental development

For hydrodynamic study of fluidized bed in this conditions has been used the next installation (figure1).

1-fluidization column;
2-air pump;
3-liquid pump;
4-liquid tank;
5-air rotameter;
6-liquid rotameter;
7-pressure gauge.

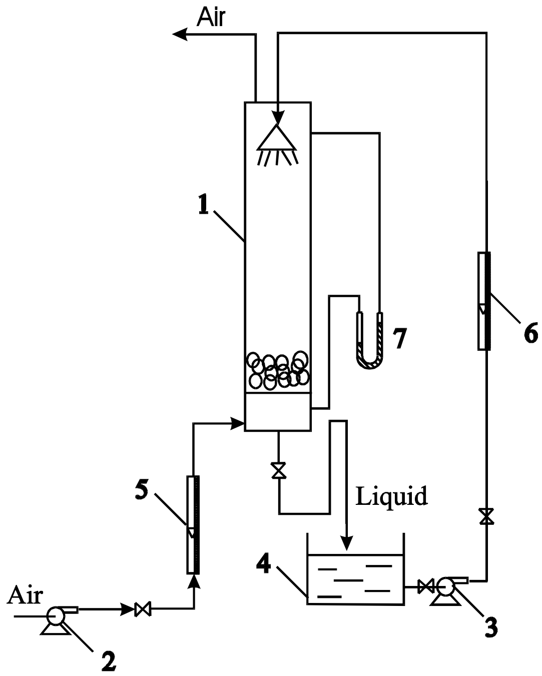

Fig.1. Installation for hydrodynamic study of fluidized bed

The gas and liquid flows is measured with liquid manometer.

The drop pressure on the bed was measured with a gas manometer.

It was measured the drop pressure, at flowing in column without filling and at different hights of filling (h_0). It was used two columns for determination of optimum h_0/D ratio at what fluidization has no secondary effects.

The quality of fluidization was the best than when h_0/D=0,5-0,8.

Experimental was determined that ratio D/d_p must be biger than 8 for a good fluidization.

At ratio h_0/D biger than 0,8 begin to show secondary phenomenon as pistonation and canalisation.

For once establish the conditions for a good homogenous fluidization has past away to determination on experimental way to minimumfluidization velocity. In this purpose has been followed the variation of drop pressure as a function of velocity. Has been seen the phenomenon who take place in filling bed.

In first phase it was studied the two-phase fluidized bed. The obtaining results for different work conditions can be seen in figure 2.

The results obtained in conditions of three-phase fluidized bed can be seen in figures 3,4,5 for different tipes of fillings.

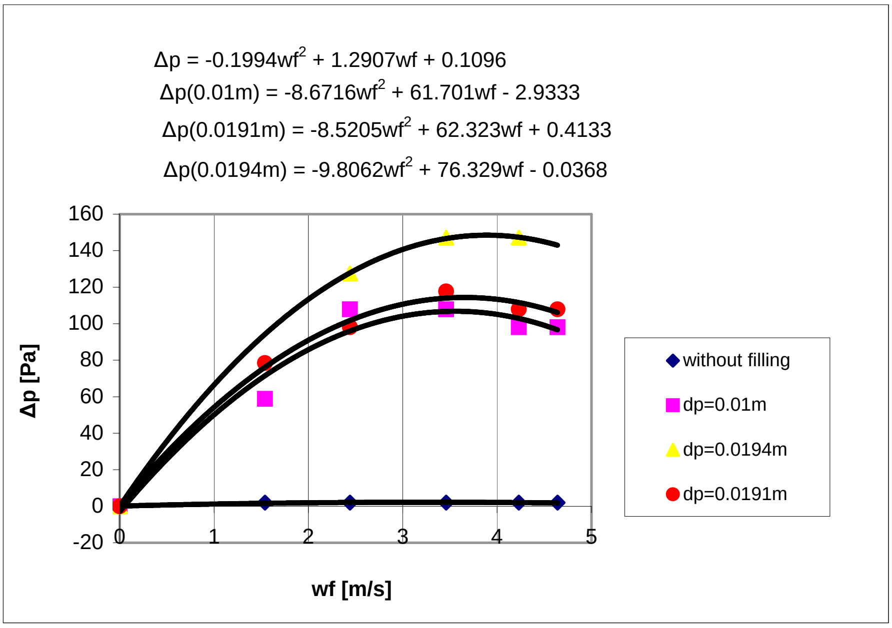

Fig.2. Pressure drop on different types of fillings

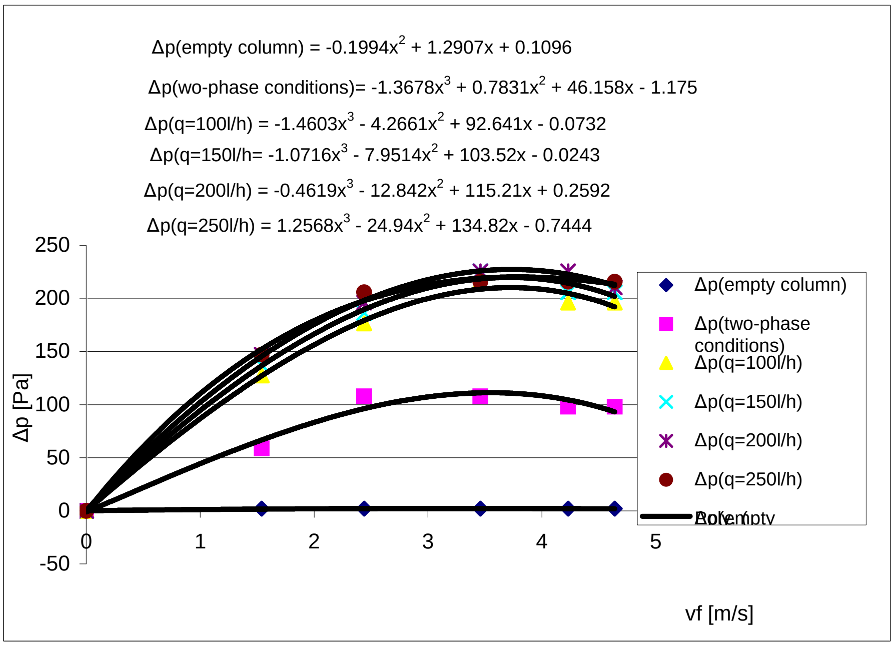

Fig.3. Pressure drop on the filling with particles diameter d_p = 0,01 m

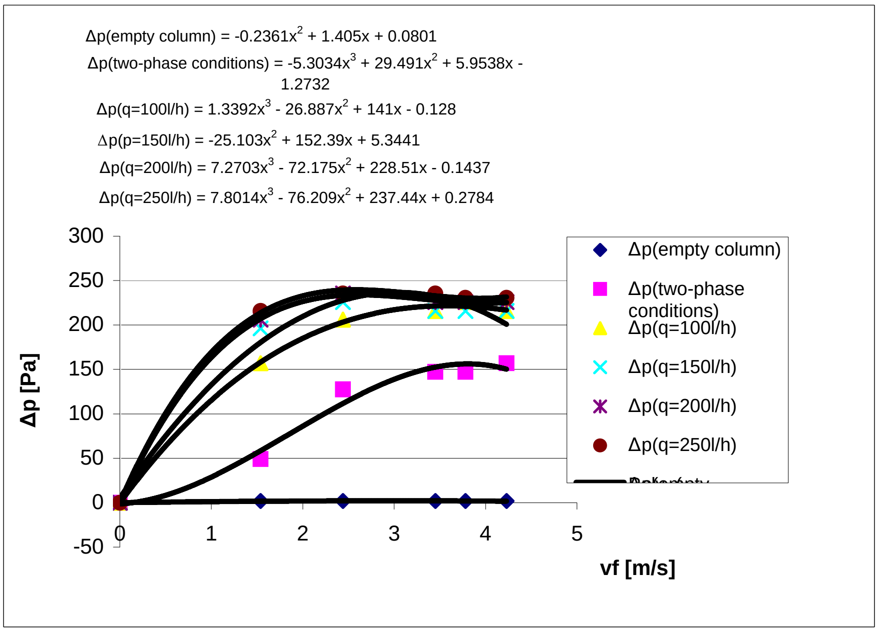

Fig.4. Pressure drop on the filling with particles diameter d_p = 0,0194 m

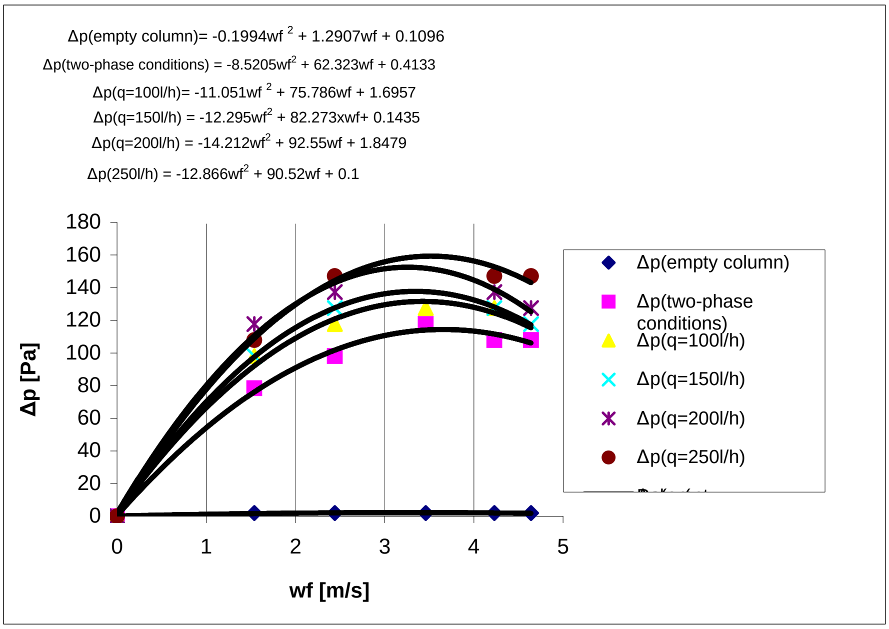

Fig 5. Pressure drop filling with particles diameter d_p = 0,0191 m

In all cases has been observed an improving of fluidization quality in condition of three-phase fluidization.

The fluid film formed on filling surface had replaced the gas-solid friction with the gas-liquid friction. Also was observed that the pressure drop is bringing up a little with sprinkling density.

Analysis of experimental results

The analysis of experimental results suggest that minimum fluidization velocity is bringing up in limits of (10-20%) once with growing of sprinkling density.

For establish a calculation relation for minimum fluidization velocity in three-phase fluidization conditions it was necessary to establish a new relation for minimum fluidization velocity in two-phase conditions.

In this purpose it was been made the diagram $\varepsilon_0 \cdot Ar = f(Re)$, figure 6.

In the second phase it was corelate the minimum fluidization velocity, determined experimental, with sprinkling density.

$$\varepsilon_0 Ar = \left(\mathrm{Re}_p\right)^x \quad (1)$$

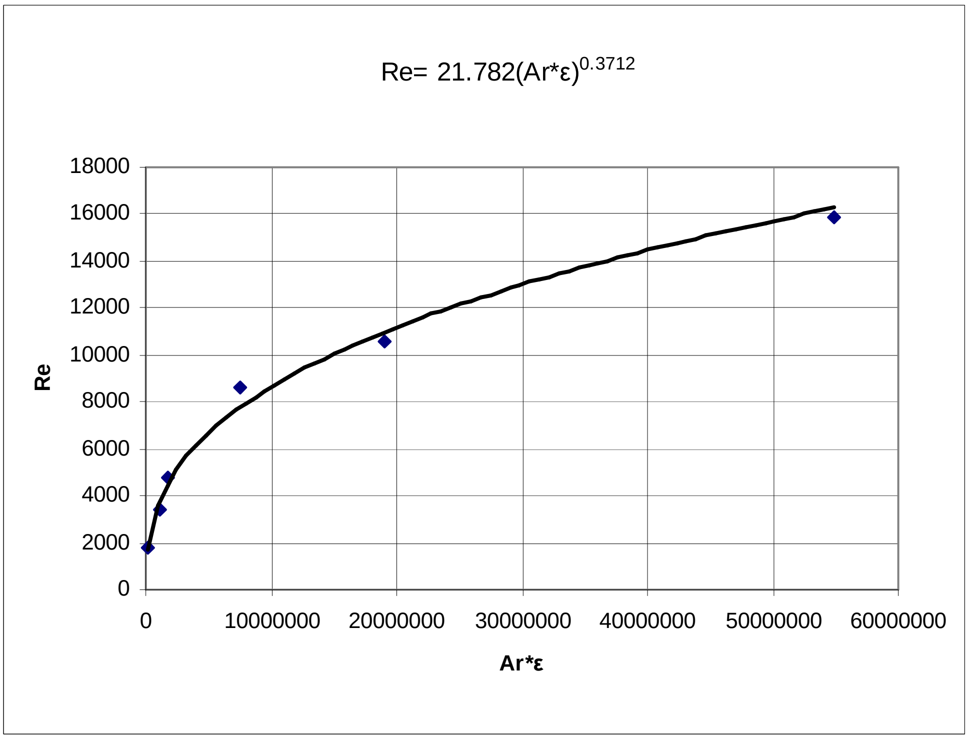

Fig.6. Dependence of Reynolds number of $\varepsilon_0 \cdot Ar$

The results are presented in table 2 and figure 7.

The relation who was determined for minimum fluidization velocity is:

$$w_f = \frac{(\varepsilon_0 Ar)^x \cdot \eta_f}{0{,}001 \cdot d_p \cdot \rho_f}. \quad (2)$$

Table 2.

Minimum fluidization velocity

dp [m]	$\varepsilon_0 \cdot Ar$	q [l/m²h]	x	wf [m/s]	x = f(q)
0,1	131622,2	6,49 9,74 12,99 16,24	9,827 9,372 9,033 8,756	4,24 4,5 4,7 4,9	$x = 10,526 \cdot e^{-0,0118 \cdot q}$
0,0191	1087409	6,49 9,74 12,99 16,24	12,016 11,603 11,308 11,079	2,317 2,41 2,49 2,55	$x = 12,632 \cdot e^{-0,0083 \cdot q}$
0,0194	1722981	6,49 9,74 12,99 16,24	12,471 12,056 11,758 11,526	2,27 2,36 2,43 2,62	$x = 13,091 \cdot e^{-0,008 \cdot q}$

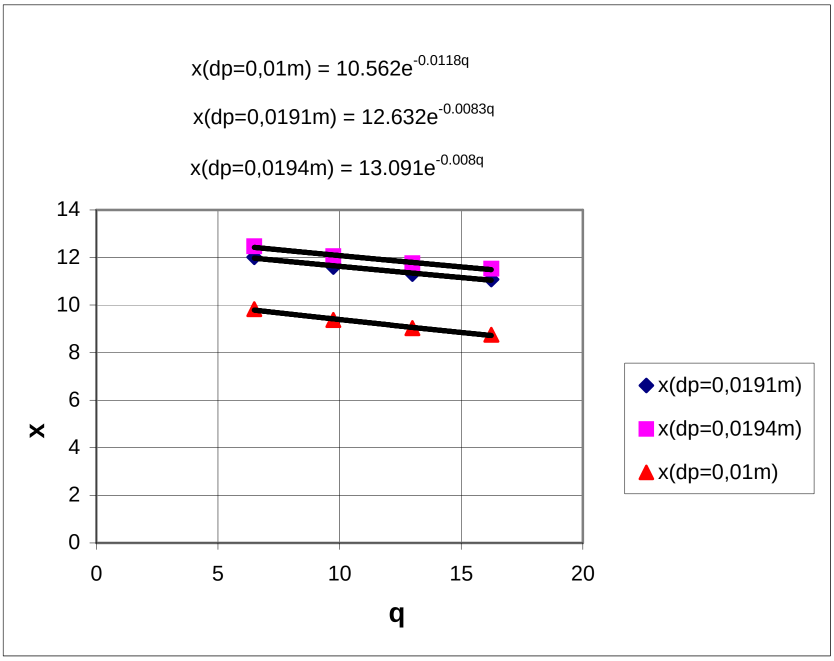

Fig.7. Dependence of x by sprinkling density

The pressure drop on fluidized bed is infuenced by d_p, ρ_p, q. The dependence is presented in figures 8 and 9.

It can be observed that Δp it is minimum at ratio h_0/D = 0,5-0,7. In this conditions the fluidization quality it is better too.

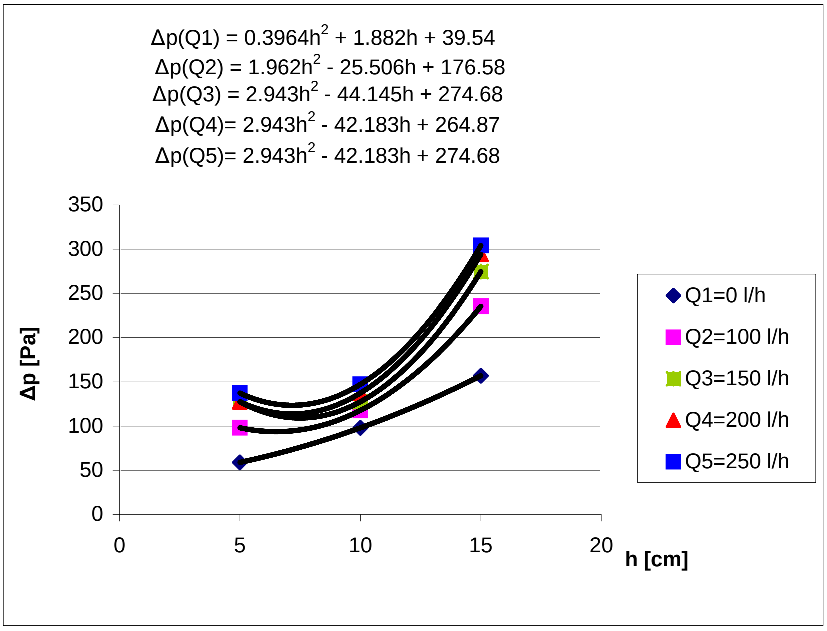

Fig.8. Dependence of pressure drop by sprinkling density

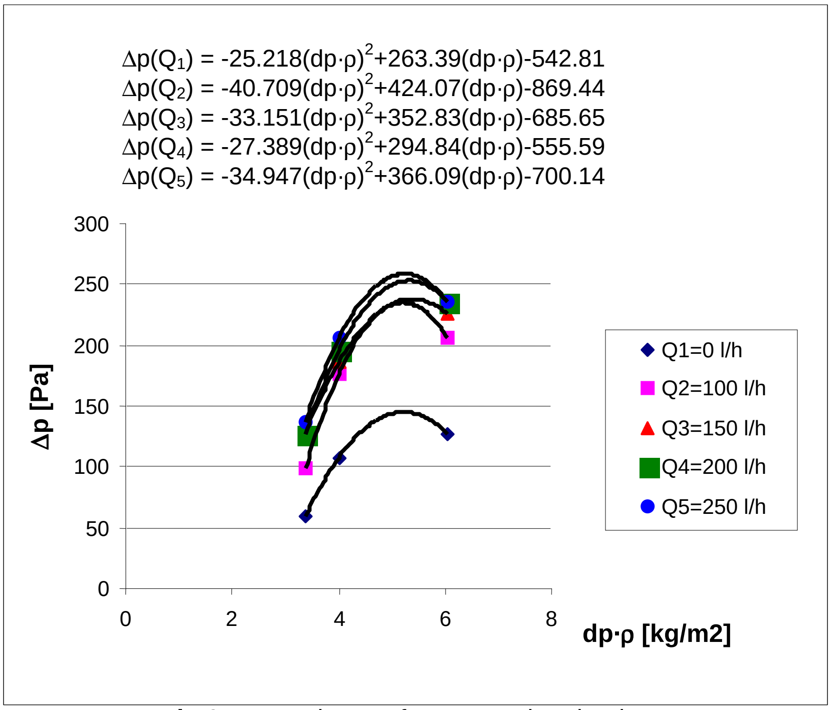

Fig.9. Dependence of pressure drop by dp·ρ

Conclusions

It was establish a new calculation relation for minimum fluidization velocity in condition of two-phase fluidization for filling corps with high diameter and small density.

The experimental data have been corelated in a new calculation relation for minimum fluidization velocity in three-phase fluidization case and it was establish the relation between minimum fluidization velocity and sprinkling density.

It was determined the relation between pressure drop and sprinkling density I three-phase conditions, establishing the ratio h_0/D = 0,5-0,7 for minimum drop pressure on the filling bed.

It is necessary the research continuation for establish the corelation between pressure drop and sprinkling density as well as determination of minimum fluidization velocity for more different filling corps.

Symbols

Ar = Arhimedes number;
Re = Reynolds number;
d_p = particles diameter;
ρ = particles density;
wf = minimum fluidizaton velocity;
h_0 = filling hight
D = column diameter
Δp = pressure drop.
ε_0 = goals ratio of filling

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