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Prediction of the particle circulation rate in a draft tube spouted bed suspension dryer

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Abstract: A model for predicting the particle circulation rate in a draft tube spouted bed dryer with inert particles is proposed and verified. The calculation algorithm requires three input values: the gas velocity in the draft tube, one data point for the static pressure in the draft tube, and the pressure gradient in the annulus. The particle circulation rate can be estimated by solving the continuity and momentum equations for turbulent accelerating two-phase flow. The numerical solution is based on an iterative procedure until the assumed value of the particle circulation rate produces the prescribed value of the fluid static pressure at a certain axial position. Experiments were performed in a cylindrical column of 215 mm diameter with a draft tube of 70 mm diameter and length of 900 mm. Polyetylene pellets were used as the inert particles with a diameter of 3.3 mm, a density of 921 kg/m^3 and a sphericity of 0.873. The model predictions of the particle circulation rate are in good agreement with the experimental data.

Keywords: spouted bed, draft tube, dryer, circulation rate.

INTRODUCTION

Drying in a spouted bed of inert particles has been investigated in the past for a variety of liquids, slurries and pasty materials. It appears that this technique[1] was initially developed in the former USSR by Kutsakova, Reger, Minchev, Konovalov and others. It was not widely known in other parts of the world, largely because of the language barrier. Recently, this technology has found renewed interest for the drying of liquids, slurries and pasty materials because of its ability to produce powders at moisture evaporation rates comparable to those of spray and drum dryers. The number of articles on this subject is growing considerably, mainly concerning food processing: bovine blood, eggs, vegetable extract, tomato pulp, fruits pulps, yeast, molasses, milk and corn starch.[2] Using an inert charge, materials of

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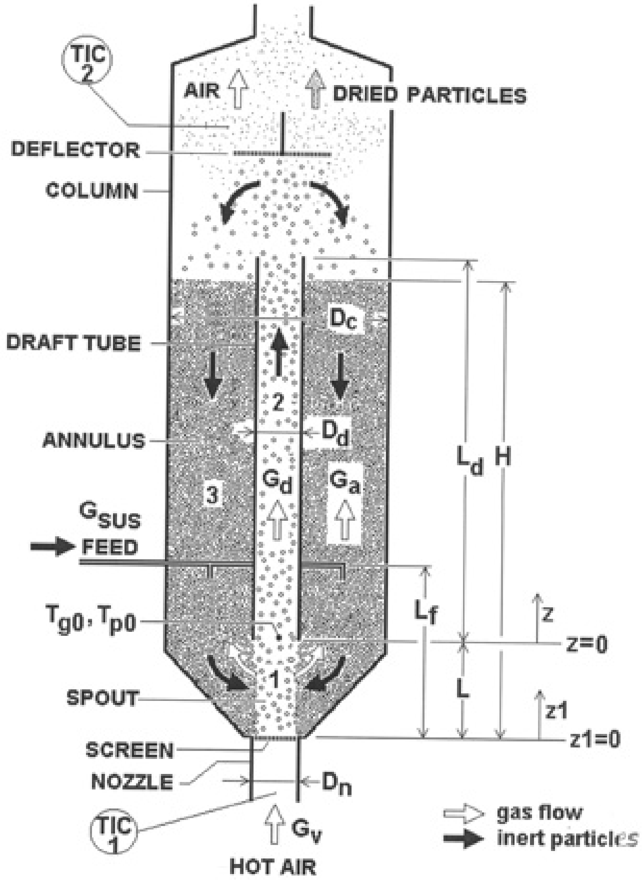

Fig. 1. Schematic diagram of the draft tube spouted bed dryer (DTSB).

high moisture content (suspensions, sludges, *etc*.) can be dried in a single step, with the process working continuously.

A schematic diagram of a spouted bed suspension dryer with a draft tube (DTSB) is given in Fig. 1. The wet material (suspension, slurry, pulp, *etc*.) is fed into a bed of inert particles, which are circulated through the draft tube. The feed can be sprayed at the top of the annulus or directly at the entrance region just below the draft tube inlet. Another way is to pump the suspension or slurry directly into the annulus at several points.

The spouted bed of circulating inert particles consists of three zones (Fig. 1), which can be distinguished both in space and in hydrodynamic character, thus, zone 1 can be characterized by turbulent inert particle flow, ensuring intensive gas–solid contact in the vicinity of the gas inlet, zone 2 by inert particles being transported vertically upward in the draft tube, co-current to the air flow and zone 3 by a densely layered annular part sliding downward, countercurrent to the air flow.

There is no particle mixing between the zone of the sliding layer and that of the vertical particle transport. Various partial processes of inert bed drying such as coating, drying and wearing of the dried coating occur in different zones of the bed, thus, an even, film-like layer (coating) is formed in zone 3, fast drying begins in the air-inlet area (zone 1), continues in the draft tube (zone 2), where also wearing of the dried coating occurs as a consequence of the intensive friction in the draft tube and collisions with the deflector.

Stable drying operation can be achieved when the total operational time of the partial processes does not exceed the cycle time of the inert particles, namely the partial processes must take place during a single circulation. The inert particles must be surface dry when they fall back on the annulus section (zone 3) to prevent their sticking together and bed sintering.

Numerous studies of suspensions drying in a spouted and a jet-spouted bed of inert particles[3–12] and in screw-type spouted bed with inert particles[13,14] have been published. The spout-fluid bed with a draft tube has been utilized by Hadzismajlovic *et al.*[15] and Povrenovic[16,17] for drying various solutions and suspensions. These authors successfully dried a wide range of materials, such as animal blood plasma, brewery yeast, skim milk, starch, red beet juice, carrot juice, soya

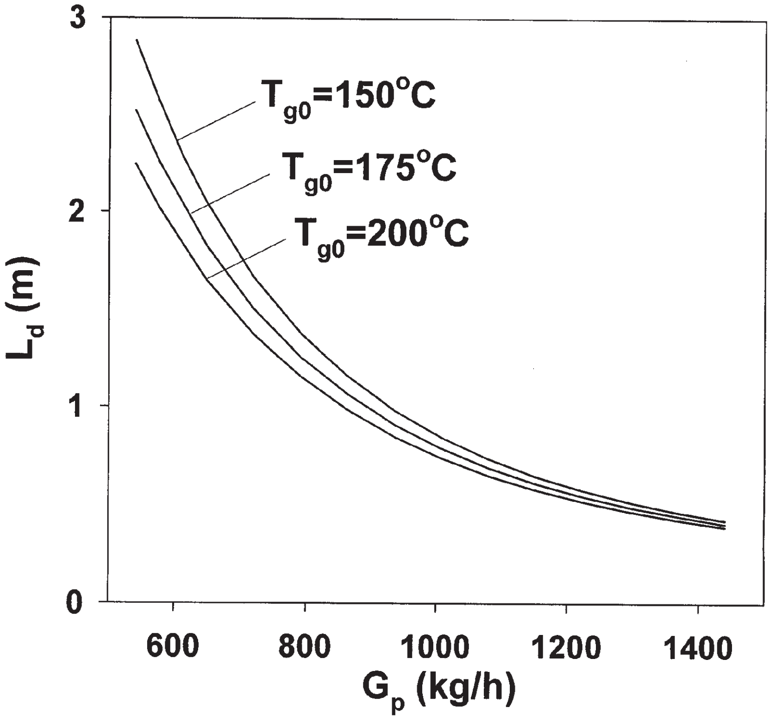

Fig. 2. The draft tube length required for complete evaporation as a function of the particle circulation rate and the inlet air temperature (G_v = 306 kg/h; G_d = 265 kg/h; G_a = 41 kg/h; T_{p0} = 73 °C; feed-water, G_{SUS} = 12 kg/h).

milk and some of theirs combinations, in a draft tube spout-fluid bed a dryer. Littman *et al.*[18] developed a model for the evaporation of water from large glass particles in a pneumatic transport regime, *i.e.*, in a draft tube spout-fluid bed dryer.

In our previous study,[19] a draft tube spouted bed dryer with inert particles was used for the drying of different suspensions. The effects of the operating conditions on the dryer throughput and product quality were investigated and a model for predicting the dryer behavior was presented and discussed. This study shows that the particle circulation rate is the most important parameter for the dryer efficiency. This is illustrated in Fig. 2, which shows the predicted draft tube length for complete evaporization as a function of the particle circulation rate for different air temperatures at the draft tube inlet. As can be seen, increasing the particle circulation rate by a factor of two reduces the required draft tube length for complete evaporization by a factor of about three. As the circulating motion of inert particles becomes more intensive, the suspension film formed on their surfaces, becomes thinner, which is desirable from the point of view of a stable drying operation. Therefore, the objective of this study was the accurate prediction of the particle circulation rate, since it is of crucial importance for the design and control of a draft tube spouted bed suspension dryer.

PARTICLE CIRCULATION RATE PREDICTION

The draft tube in a DTSB dryer is essentially a relatively short pneumatic riser, so that accelerating two-phase flow equations must be used to model the hydrodynamics.[20] The individual momentum balances for the fluid and particle phases[21] are:

$$\rho_f \frac{\mathrm{d}}{\mathrm{d}z}(\varepsilon u^2) = \varepsilon\left[-\frac{\mathrm{d}p_\mathrm{d}}{\mathrm{d}z}\right] - \varepsilon\rho_f g - \beta(u - v)^2 - F_f \tag{1}$$

$$\rho_\rho \frac{\mathrm{d}}{\mathrm{d}z}[(1-\varepsilon)v^2] = (1-\varepsilon)\left[-\frac{\mathrm{d}p_\mathrm{d}}{\mathrm{d}z}\right] + \beta(u - v)^2 - \rho_\mathrm{p} g(1-\varepsilon) - F_p \tag{2}$$

where $\beta(u - v)^2$ is the hydrodynamic drag force per unit volume of suspension. F_f and F_p are pressure losses due to fluid–wall and particle–wall friction written in terms of the friction factors f_f and f_p:

$$F_f = 2 f_f \rho_f U^2 / D_\mathrm{d} \tag{3}$$

$$F_p = 2 f_p \rho_p (1-\varepsilon) v^2 / D_\mathrm{d} \tag{4}$$

where f_f and f_p are the corresponding friction coefficients.

The continuity equations for the gas and particle phases are:

$$\frac{\mathrm{d}}{\mathrm{d}z}(u\varepsilon) = 0 \quad i.e., \quad u\varepsilon = \frac{G_\mathrm{d}}{\rho_f A_\mathrm{d}} = U \tag{5}$$

$$\frac{\mathrm{d}}{\mathrm{d}z}[v(1-\varepsilon)] = 0 \quad i.e., \quad v(1-\varepsilon) = \frac{G_p}{\rho_p A_\mathrm{d}} = c_s \tag{6}$$

Fluid–particle interphase drag coefficient, fluid–wall and particle–wall friction coefficients

The dimensionless fluid–particle interphase drag coefficient is determined from the Grbavčić *et al.*[22] model:

$$\frac{\beta}{\beta_\mathrm{mF}} = 1 - C_2 + \frac{1}{\lambda}\left[1 - \left(\lambda\frac{\varepsilon - \varepsilon_\mathrm{mF}}{1-\varepsilon_\mathrm{mF}} + C_1\right)^2\right]^{1/2} \tag{7}$$

Where the constants C_1, C_2 and λ are:

$$C_1 = [1 + (U^2_\mathrm{mF}/\varepsilon^3_\mathrm{mF} U^2_\mathrm{t})^2]^{-1/2} \tag{8}$$

$$C_2 = \frac{1}{\lambda}\sqrt{1-C_1^2} \tag{9}$$

$$\lambda = \sqrt{1-C_1^2} - C_1 \tag{10}$$

and

$$\beta_\mathrm{mF} = \frac{\varepsilon^3_\mathrm{mF}(1-\varepsilon_\mathrm{mF})g(\rho_p - \rho_f)}{U^2_\mathrm{mF}} \tag{11}$$

The fluid-wall friction term (F_f) was determined using Eq. (3) and a standard friction factor correlation:[23]

$$f_f = 0.0791 / Re^{0.25} \tag{12}$$

where the Reynolds number is based on the superficial gas velocity ($Re = D_d \rho_f U/\mu$).

A particle–wall friction term was correlated in non-accelerating experiments:[24]

$$f_p \frac{\varepsilon^3}{1-\varepsilon}\frac{U}{U_\mathrm{t}} = 0.0017\left[\frac{1-\varepsilon}{u_\mathrm{s}/U_\mathrm{t}}\right] \tag{13}$$

For a known fluid superficial velocity and particle mass flowrate, the continuity equations and the momentum balances could be integrated numerically in order to obtain the axial variation of the particle velocity, voidage and pressure gradient in the transport tube ($z > 0$, Fig. 1).

Using the continuity above the feeding point ($z > 0$) momentum balances (Eqs. (1) and (2)) become:

$$-\frac{\mathrm{d}p_{\mathrm{d}}}{\mathrm{d}z}=\frac{1}{\varepsilon}\left[\beta(u-v)^2+\rho_f g\varepsilon+F_f-\rho_f u^2\frac{\mathrm{d}\varepsilon}{\mathrm{d}z}\right] \tag{14}$$

$$-\frac{\mathrm{d}p_{\mathrm{d}}}{\mathrm{d}z}=[\rho_{\mathrm{p}}(1-\varepsilon)+\rho_f\varepsilon]g+F_f+F_p+\gamma\frac{\mathrm{d}\varepsilon}{\mathrm{d}z} \tag{15}$$

where $\gamma=\rho_{\mathrm{p}}v^2-\rho_f u^2$.

From Eqs. (14) and (15) one obtains:

$$\frac{\mathrm{d}\varepsilon}{\mathrm{d}z}=\frac{\beta(u-v)^2-\varepsilon[(\rho_p-\rho_f)g(1-\varepsilon)+F_{\mathrm{p}}]+F_f(1-\varepsilon)}{(\rho_p v^2-\rho_f u^2)\varepsilon+\rho_f u^2} \tag{16}$$

Since the air introduced into the column partially penetrates into the annulus in a DTSB, the air mass flowrate through the draft tube can be determined using material balance:

$$G_v=G_d+G_a \tag{17}$$

Boundary conditions

The general force balance for the spout particles (the region between $z1 = 0$ and $z1 = L$, Fig. 1) is:[25]

$$\frac{v^2}{z1}+v\frac{\mathrm{d}v}{\mathrm{d}z1}=\frac{\beta(u-v)^2}{\rho_p(1-\varepsilon)}-\frac{(\rho_p-\rho_f)g}{\rho_p} \tag{18}$$

In a previous study,[19] it was shown that the solids superficial velocity and the air superficial velocity in the spout both vary linearly with height, *i.e.*, between $zl = 0$ and $zl = L$, hence:

$$v(1-\varepsilon)=c_{\mathrm{s}}\frac{z1}{L} \tag{19}$$

$$U=\frac{4}{\rho_f\pi D_{\mathrm{d}}^2}\left(G_v-G_a\frac{z1}{L}\right) \tag{20}$$

EXPERIMENTAL

The data for the particle circulation rate were collected during drying experiments conducted using the system described in detail in our previous work.[19] The drying chamber was a cylindrical column D_c = 215 mm i.d. in the lower part and 320 mm i.d., in the upper part. The overall column height was 1655 mm, while the effective column height (above the nozzle) was 1400 mm. Air was introduced into the drying section through the nozzle D_n = 70 mm i.d. The base of drying section was conical (45°). The draft tube (D_{d} = 70 mm i.d. and L_d = 900 mm) was mounted axially above the nozzle with a possibility of changing the distance between the top of the nozzle and the draft tube (*L*, Fig. 1). A deflector was placed above draft tube at $z1$ = 1300 mm.

The inert particles were polyethylene beads with an equal volume sphere diameter of 3.3 mm and a particle density of 921 kg/m^3. The estimated inert particle sphericity was 0.873. In all runs, the annulus bed height (*H*) was 900 mm.

The overall air flowrate was measured by a calibrated orifice connected to a water manometer. The air flowrate in the annulus was measured indirectly, by measuring the pressure gradient in the annulus ($-dp_a/dz$). To obtain the corresponding velocity there, a calibration plot was prepared by measuring the pressure gradient *vs*. velocity relationship in a fixed bed of polyethylene particles in a column 60 mm in diameter. The data were correlated as a relationship between the modified friction factor for a packed bed and the particle Reynolds number for the annulus. It was assumed that the voidage in the moving bed annulus would be the same as in the fixed bed. The resulting correlation is:

$$f_{pA} = 94.7 / Re_{pA} + 0.979 \tag{21}$$

The particle circulation rate was determined by measuring the velocity of a tracer particle in the annulus through a glass window and using the relation:

$$G_p = \rho_p A_a (1 - \varepsilon_a) v_a \tag{22}$$

The suspension was introduced into the center of the annular zone 400 mm from the bottom (L_f, Fig. 1) using four tubes 4 mm in diameter.

A temperature controller TIC1 maintained the inlet air temperature at the desired level. A thermo controller TIC2, which was situated at the top of the column controlled a feeding pump in order to keep the exit air temperature constant. The volumetric flowrate of the suspension into the column was measured by recording the suspension level in a slurry tank over a certain period of the time. Using the actual suspension density for each material, the suspension mass flowrate can be calculated.

Althogether, 19 drying runs were conducted with water as the ideal feed and with calcium carbonate, calcium stearate and Zineb fungicide suspensions. The minimum fluidization parameters (U_{mF} and E_{mF}) required to calculate the variational constants for the prediction of the drag coefficients were determined using the Ergun[26] equation. The inert particle terminal velocity (U_t) was determined using equations proposed by Kunii and Levenspiel.[27] A summary of the experimental conditions is given in Table I.

TABLE I. Experimental conditions for different suspensions

Run	Feed	L/m	G_v/(kg/h)	G_{sus}/(kg/h)	T_{g0}/°C	T_{p0}/°C	$p_d{}^a$/Pa	G_p/(kg/h)
1	Water; $x_{H_2O} = 1$	0.05	306	4.80	141.1	73.0	226	868
2		0.05	302	8.35	139.7	37.4	207	864
3		0.05	304	9.88	134.4	32.0	223	936
4		0.05	295	6.25	172.3	51.0	234	1076
5		0.05	288	9.63	176.0	45.0	220	1080
6		0.05	287	12.68	176.0	38.0	239	1044
7		0.05	284	12.45	200.0	37.8	228	1037
8		0.05	283	9.65	200.0	70.0	236	986
9		0.08	274	5.98	157.1	78.7	295	1370
10		0.08	267	7.00	174.0	85.0	300	1479
11		0.11	269	5.75	157.1	75.0	250	1269
12		0.11	263	6.93	168.1	78.3	265	1187
13	$CaCO_3$; x_{H_2O} = 0.70	0.05	308	9.99	141.2	56.0	115	364
14		0.08	297	8.37	149.0	56.0	–	1109
15		0.08	294	17.57	167.3	43.0	–	1224
16	Ca-strearate; $x_{H_2O} = 0.82$	0.08	281	17.22	168.3	47.0	260	1357
17		0.08	279	9.30	167.5	58.3	300	1519
18	Zineb fungicide; $x_{H_2O} = 0.75$	0.08	286	25.31	171.0	45.5	220	1076
19		0.08	264	14.94	171.7	35.0	215	652

$^a z = 0.424$ m

RESULTS AND DISCUSSION

An important advantage of a DTSB dryer is that suspensions and slurries containing organic and biological compounds, can be dried[15–17] since the high friction in the draft tube as well as collision of the inert particles with a deflector minimizes the risk of bed sintering. Bed sintering is most undesirable during the operation of a dryer, since it causes a dramatic increase in the moisture content of the product or of the outlet air temperature. The first symptom of bed sintering in a DTSB dryer is a decrease in the inert particle circulation rate,[19] hence the proposed model can be used as a basis for the development of control software. In certain applications,[19] bed sintering can be prevented by the introduction of pure water instead of suspension for a short time period in order to clean the inert particles and hence prevent enhanced deposition of wet material on them. The frequency and duration of the cleaning period can be controlled on the basis of on-line calculation of the particle circulation rate. Regarding the complexity associated with a drying operation and to the problems arising from a draft tube spouted bed working as dryer in certain applications, the implementation of such a control strategy in a suspension drying process can be helpful in order to maintain a satisfactory product quality and a stable operation of the dryer.

The continuity and momentum equations contain four dependent variables (u, v, ε and $-\mathrm{d}p_{\mathrm{d}}/\mathrm{d}z$) and three parameters ($F_f$, F_p and β). For specified two values, for example the fluid and particle flowrates (G_{d} and G_{p}), the general equations reduce to two independent equation, hence in the calculations, two variables should be selected as input values. In the present case, the particle mass flowrate G_p, *i.e.*, particle velocity and voidage since $G_p = \rho_p A_{\mathrm{d}} v(1-\varepsilon)$, was required to be predicted, hence an iterative procedure had to be applied. Since in a DTSB, the air introduced into the column partially penetrate into the annulus, the air mass flowrate through the draft tube can be determined using Eq. (17), but an additional input value is required and that is the pressure gradient in the annulus. Finally, the input values for the model are air mass flowrate at the column inlet (G_v), the pressure gradient in the annulus ($-\mathrm{d}p_{\mathrm{a}}/\mathrm{d}z$) and the fluid static pressure in the draft tube at $z = 0.424$ m [$p_{\mathrm{d}}(0.424)$]. The calculation algorithm is:

1. Assume particle circulation rate, *i.e.*, particle flowrate in the draft tube (G_p).
2. Calculate the air mass flowrate through the annulus using the data for the pressure gradient in the annulus ($-\mathrm{d}p_{\mathrm{a}}/\mathrm{d}z$) and Eq. (21). Calculate the air mass flowrate through the draft tube using Eq. (17).
3. Calculate the draft tube inlet conditions through numerical integration of Eq. (18), combined with Eqs. (19) and (20). The boundary conditions are $v = 0$ and $\varepsilon = 1$ at the spout base, *i.e.*, at $z1 = 0$ ($z = -L$). The calculated flow parameters at the top of the spout ($z = 0$) represent at the same time the inlet parameters for the draft tube, *i.e.*, $(v)_{z=0} = v_0$ and $(\varepsilon)_{z=0} = \varepsilon_0$.
4. Numerically integrate Eq. (16) in order to obtain the voidage distribution

along the draft tube. In this calculation, F_f is obtained using Eqs. (3) and (12), F_p is obtained using Eqs. (4) and (13) while β is obtained from Eq. (7). The gas and particle phase velocities are then calculated from the continuity (Eqs. (5) and (6)) and $(-dp_d/dz)$ is calculated using Eq. (14) or Eq. (15). The boundary condition for Eq. (14) is the voidage at the feeding line ε_0.

5. Numerically integrate the pressure gradient along the transport line axis in order to obtain the axial static pressure distribution in the draft tube.
6. Compare the calculated value of the fluid static pressure in the draft tube at z = 0.424 m with the experimental value.
7. If $p_{d,calc}(0.424) \neq p_{d,exp}(0.424)$ repeat procedure with a new assumption for G_p.

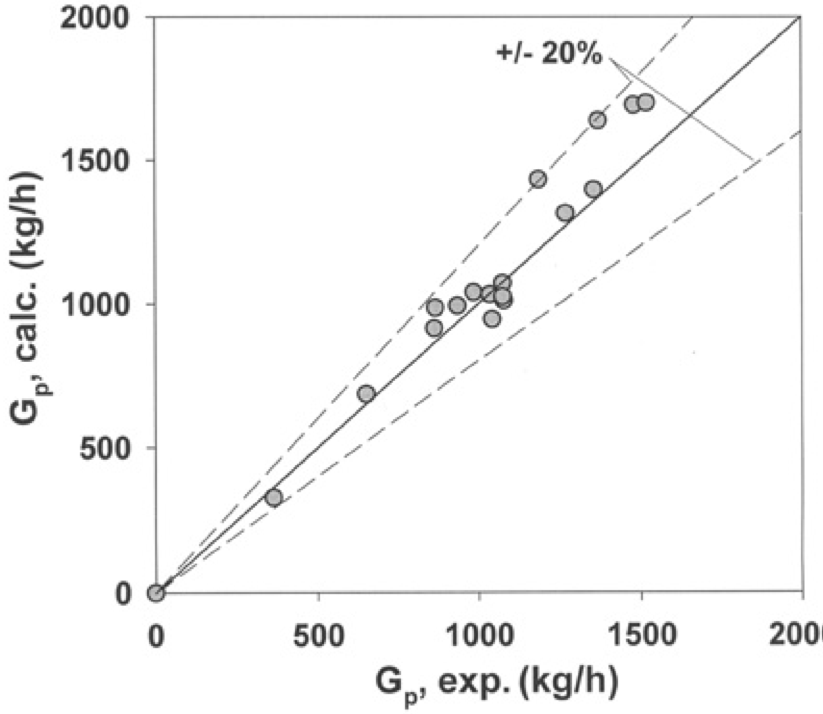

Fig. 3. Comparison between the calculated and measured values of the particle circulation rate.

A comparison between the experimental and calculated values of G_p is shown in Fig. 3. As can be seen, the agreement is quite good with a mean absolute deviation between the calculated and experimental values of 8.2 %.

CONCLUSIONS

A model for predicting the particle circulation rate in a draft tube spouted bed is proposed and discussed. Although the model equations are generally applicable for a vertical two-phase dilute flow, the proposed method for predicting the draft tube inlet conditions is restricted to the cases where a spouted bed type feeding device is used.

The model gives an accurate prediction of the particle circulation rate with a mean absolute deviation between the calculated and experimental values of 8.2 %.

Acknowledgement: Financial support of the Ministry of Science and Environmental Protection of Serbia is gratefully acknowledged.

NOMENCLATURE

A – Cross-sectional area, m^2
c_s – Particle superficial velocity in the draft tube [$G_p/(\rho_p A_d)$], m/s
C_1, C_2 – Constant in Eq. (7)
d_p – Inert particle diameter (volumetric), m
D – Diameter, m
f_f – Fluid–wall friction coefficient
f_p – Particle–wall friction coefficient
f_{pA} – Modified friction factor for the flow in the annulus [$f_{pA}=(-\mathrm{d}p_a/\mathrm{d}z)[d_p/(\rho_f U_a^2)(\varepsilon_a^3/(1-\varepsilon_a)]$]
F_f – Pressure gradient due to the fluid–wall friction, Pa/m
F_p – Pressure gradient due to the particle–wall friction, Pa/m
g – Gravitational acceleration, m/s^2
G_a – Air mass flowrate in the annulus, kg/s
G_d – Air mass flowrate in the draft tube, kg/s
G_{H_2O} – Water flowrate in the suspension ($=x_{H_2O} \cdot G_{SUS}$), kg/s
G_p – Inert particle mass flowrate in the draft tube (particle circulation rate), kg/s
G_{SUS} – Suspension feed rate, kg/s
G_v – Air mass flowrate at the column inlet, kg/s
H – Packed bed height in the annulus (see Fig. 1), m
L – Separation length between the bed bottom and the draft tube inlet (see Fig. 1), m
L_f – Vertical coordinate at which the feed is introduced (see Fig. 1), m
L_d – Length of the draft tube, m
p – Static fluid pressure, Pa
Re – Reynolds number in the draft tube, based on the fluid superficial velocity [$Re = d_d \rho_f U_a/\mu(1-\varepsilon_a)$]
Re_{pA} – Reynolds number for the annulus [$Re_{pA} = (d_p \rho_f U_a)/\mu(1-\varepsilon_a)$]
T_g – Air temperature in the draft tube, ºC
T_p – Particle temperature in th draft tube, ºC
u – Mean interstitial fluid velocity in the draft tube and in the spout ($u = U/\varepsilon$), m/s
u_s – Slip velocity between the fluid and the particles in the draft tube ($u_s = u-v$), m/s
U – Superficial fluid velocity, m/s
U_a – Superficial fluid velocity in the annulus, m/s
U_{mF} – Superficial fluid velocity at minimum fluidization, m/s
U_t – Particle terminal velocity in an infinite medium, m/s
v – Radially averaged particle velocity in the draft tube and in the spout, m/s
v_a – Particle velocity in the annulus, m/s
x_{H_2O} – Water content of the suspension, kg_{H_2O}/kg_{SUS}
z – Vertical coordinate measured from the draft tube entrance (Fig. 1), m
$z1$ – Vertical coordinate measured from the column bottom (Fig. 1), m

Greek letters

β – Fluid–particle interphase drag coefficient, kg/m^4
β_{mF} – Fluid–particle interphase drag coefficient in a particulately fluidized bed at minimum fluidization, kg/m^4

ε – Voidage in the draft tube and in the spout
ε_a – Voidage in the annulus
ε_{mF} – Voidage at minimum fluidization
λ – Constant in Eq. (7)
γ – Defined in Eq. (15) [$\gamma = \rho_p v^2 - \rho_f u^2$], kg/(m s^2)
μ – Viscosity of the fluid, Ns/m^2
ρ_f – Fluid density, kg/m^3
ρ_p – Particle density, kg/m^3

Subscripts

0 – Refers to the draft tube inlet (z = 0)
a – Annulus
c – Column
d – Draft tube
n – Nozzle
p – Inert particle

ИЗВОД

ПРЕДВИЂАЊЕ ЦИРКУЛАЦИЈЕ ЧЕСТИЦА У СУШИОНИКУ ЗА СУСПЕНЗИЈЕ СА МОДИФИКОВАНИМ ФОНТАНСКИМ СЛОЈЕМ

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Постављен је модел за предвиђање брзине циркулације честица у сушионику са фонтанским слојем инертних честица и централном цеви. Предложени модел је експериментално верификован. У алгоритму прорачуна егзистирају три величине као познате (улазни параметри): брзина гаса кроз централну цев, једна вредност статичког притиска у централној цеви и градијент притиска у ануларној зони. Брзина циркулације честица се израчунава из једначина континуитета и биланса количине кретања за турбулентни двофазни ток флуид–честице. Нумеричко решавање се заснива на методи пробе и грешке, итеративним поступком, све док се на основу предпостављене вредности брзине честица не добије вредност статичког притиска флуида која је једнака измереној вредности на одређеној аксијалној позицији у централној цеви. Експериментална испитивања су изведена у колони пречника 215 mm са централном цеви пречника 70 mm и дужине 900 mm. Фонтански слој је образован од несферичних полипропиленских честица еквивалентног пречника 3,3 mm, сферичности 0,873 и густине 921 kg/m^3. Добијени резултати за брзину честица у централној цеви су у доброј сагласности са експерименталним подацима.

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