# The gas holdup in a multiphase reciprocating plate column filled with carboxymethylcellulose solutions

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*Abstract:* Gas holdup was investigated in a gas–liquid and gas–liquid-solid reciprocating plate column (RPC) under various operation conditions. Aqueous carboxymethylcellulose (sodium salt, CMC) solutions were used as the liquid phase, the solid phase was spheres placed into interplate spaces, and the gas plase was air. The gas holdup in the RPC was influenced by: the vibration intensity, *i.e.*, the power consumption, the superficial gas velocity, the solids content and the rheological properties of the liquid phase. The gas holdup increased with increasing vibration intensity and superficial gas velocity in both the two- and three-phase system. With increasing concentration of the CMC PP 50 solution (Newtonian fluid), the gas holdup decreased, because the coalescence of the bubbles was favored by the higher liquid viscosity. In the case of the CMC PP 200 solutions (non-Newtonian liquids), the gas holdup depends on the combined influence of the rheological properties of the liquid phase, the vibration intensity and the superficial gas velocity. The gas holdup in the three-phase systems was greater than that in the two-phase ones under the same operating conditions. Increasing the solids content has little influence on the gas holdup. The gas holdup was correlated with the power consumption (either the time-averaged or total power consuption) and the superficial gas velocity.

*Keywords:* reciprocating plate column, gas holdup, multiphase systems, carboxymethylcelulose.

## INTRODUCTION

An efficient oxygen mass transfer from the gas to the liquid phase and favorable hydrodynamic characteristics are the main reasons why the reciprocating plate columns (RCP) has been ranked as the bioreactor of the new generation.[1] The mechanical agitation in a RPC is achieved by a set of perforated plates fixed to a

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shaft at equally spaced intervals, which axially moves up-and-down through the column. The combination of aeration and agitation enables intensive mass transfer from the gas to the liquid phase with small operational costs. The RPC has found application in aerobic wastewater treatment,[2] the production of citric acid, antibiotics,[3] and ethanol,[4] as well as in the biosynthesis of extracellular polysaccharides, such as dextran[5] and pullulan.[6,7]

The Newtonian rheological behavior of the initial nutrition medium is characteristic for extracellular polysaccharide fermentations. It usually has a low viscosity which changes into non-Newtonian behavior as the polysaccharide production proceeds. The concentration, structure, molecular weight and molecular weight distribution of the formed polysaccharide are the major determinants of the rheological behavior of the fermentation broth. The oxygen mass transfer rate from the dispersed gas bubbles to the liquid, and thus the oxygen supply to the microoranisms, is hindered by the increased liquid viscosity and the non-Newtonian rheological behavior of the fermentation broth; inhomogeneity within the bioreactor is also attributed to these physical properties. The uniform distribution of the shear within the interplate spaces is an important characteristics of RPCs as mixing devices which is based on the reciprocating axial movement of the perforated plates, resulting in an efficient gas dispersion and a reliable scale-up. The homogeneous mixing of the gas–liquid dispersion in the interplate spaces and the high rate of oxygen mass transfer make this type of mixing device very suitable for extracellular polysaccharide fermentations under aerobic conditions.[6,7]

The gas holdup greatly affects both the interfacial area and the oxygen mass transfer rate in multiphase RPCs. It generally depends on the geometry of the RPC, the operation conditions (vibration intensity and superficial gas velocity), the type and content of solid phase, and the properties of the liquid. In the range of low agitation intensities, the gas holdup in a gas–liquid RPC decreases[8–13] or remains the same [14–16] with increasing vibration intensity (the product of the vibration amplitude and frequency). At higher agitation intensities, the gas holdup increases with increasing vibration intensity because of the enhanced bubble dispersion resulting from the intensive mixing. By increasing the superficial gas velocity up to a value of 3 cm/s,[8–11,14,17] the gas holdup increases, due to the increased drag to gas flow through the plate holes. When the number of plates is increased, the gas holdup increases because of the more efficient gas dispersion and the increased drag to gas flow through the perforated plates.[10,11,14,17] The presence of solid particles in the interplate spaces produces greater gas holdups, compared to the corresponding gas–liquid system, because of the intensification of gas dispersion by the solid particles.[18] There is little information in the literature on the gas holdup in RPCs filled with non-Newtonian liquids.[19] The available data are insufficient for more complete conclusions on the influence of the rheological properties on the gas holdup in RPCs, contrary to other common types of bioreactors, such as bubble columns[20,21] and air-lift reactors.[22]

In this work, the gas holdup in a RPC filled with aqueous solutions of carboxy-methylcellulose (sodium salt, CMC) of different molecular weights (*i.e.*, degree of polymerization) was investigated under various operating conditions. CMC Solutions of different concentration (0.5, 1.0, and 2.0 %), which exhibit Newtonian or pseudo-plastic rheological behavior, were used as models of extracellular polysaccharide fermentation broths, simulating in this way the increase in the concentration and molecular weight of the polysaccharide with the progress of the fermentation. The scope of the work was to evaluate the influence of the rheological behavior of the liquid phase and the operating conditions (vibration intensity, superficial gas velocity and volume content of solid particles) on the gas holdup in a multiphase RPC.

## EXPERIMENTAL

The schematic presentation of the experimental setup, consisting of a 9.2 cm i.d. column with a set of equally spaced perforated plates attached to stainless steel shaft, and the auxcillary equipment, is presented in Fig. 1. The geometry of the RPC and the operating conditions are given in Table I. The set of perforated plates was driven by a variable speed motor (360 W). The amplitude of the reciprocating movement (half of a stroke) was 2.35 cm. The frequency of reciprocation, changed up to 6 Hz by varying the rotary speed of the motor, was measured by means of an infra red optoelectronic switch.
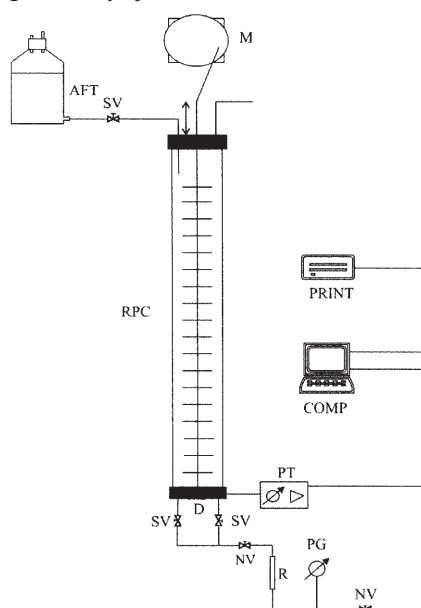


Fig. 1. Schematic drawing of the experimental set-up (AFT – aqueous feed tank; D – air distributor; M – drive motor; NV – needle valve; PG – pressure gauge; PT – pressure transducer and amplifier; R – rotameter; RPC – reciprocating plate column; and SV – solenoid valve)

TABLE I. Geometric characteristics of the RPC and the operating conditions

| Column diameter/cm | 9.20 |
|---|---|
| Column length/cm | 105 |
| Dispersion height/cm | 85.6 |
| Dispersion volume, cm$^3$ | 5687 |
| Number of plates | 15 |

TABLE I. Continued

| | |
|---|---|
| Plate diameter/cm | 9.0 |
| Plate hole diameter (internal/extremal)/cm | 0.6/0.8 |
| Plate thickness/cm | 0.1 |
| Fraction free plate area/% | 45.4 |
| Spacing between plates/cm | 5.0 |
| Length of tie-rod/cm | 12.36 |
| Amplitude of reciprocation/cm | 2.35 |
| Frequency of vibrations/$s^{-1}$ | 2–5.5 |
| Superficial gas velocity/(cm/s) | 0.5, 1.0 and 1.5 |
| Solids content/% by volume | 3.84   6.61 |
| Number of spheres per interplate space | 52   90 |

Air of room temperature, used as the gas phase, was fed through two nozzles at the bottom of the column. The gas flow rate was measured by a rotameter. The static pressure of the air near the rotameter was measured by a manometer. The liquid phase, used as a batch, were aqueous solutions of CMC of different degrees of polymerization (type Lucel PP 50 and Lucel PP 200; 'Lucel' Lučani), the concentrations of the solutions being 0.5, 1.0 and 2.0 %. The physical properties of the solutions, given in Table II, were measured using a picnometer, a stalagmometer and a rotational viscometer (Haake rotovisco RV 20) at 20 °C. Irrespective of the solution concentration up to 2 %, the CMC PP 50 solutions were Newtonian liquids, while the CMC PP 200 solutions were non-Newtonian pseudoplastic liquids. Polypropylene spheres (diameter: $8.3 \pm 0.1$ mm, and density 930 kg/m$^3$) were used as the solid phase. The spheres were placed in the interplate spaces (52 or 90 spheres per inteplate space, corresponding to solids contents of 3.84 and 6.61 % by volume, respectively). These contents of the solid phase were shown to enable the maximum gas holdup in a RPC.[18]

TABLE II. Physical properties of the liquid phase at 20 °C

| Liquid | Concentration % | Density/(kg/m)$^3$ | Surface tension N/m | Consistency coefficient/mPa s$^n$ | Power law index 1 |
|---|---|---|---|---|---|
| Glycerol | 69 | 1180 | - | 21.5 | 1.0 |
| CMC PP 50 | 0.5 | 1003 | 0.0875 | 3.0 | 1.0 |
| | 1.0 | 1005 | 0.0873 | 5.8 | 1.0 |
| | 2.0 | 1010 | 0.0870 | 16.8 | 1.0 |
| CMC PP 200 | 0.5 | 1003 | 0.0871 | 15.4 | 0.93 |
| | 1.0 | 1006 | 0.0870 | 67.1 | 0.85 |
| | 2.0 | 1010 | 0.0832 | 907 | 0.70 |

The gas holdup was measured by a method based on the direct measurement of the liquid volume retained in the column after the gas flow was stopped and the motor was switched off. Previously, the height of the void fraction of the column was correlated to the volume of liquid flowing out of the column until the height of the dispersion was set to the predetermined level. The gas holdup was calculated as the volume of dispersed gas divided by the volume of dispersion, which was held constant regardless of the operating conditions.

The instantaneous power consumption was calculated by a computer program from the instantaneous pressure variation at the bottom of the column, measured by a differential pressure transducer (IHTM, Belgrade, Model TPr-100.05, range – 50 to 50 kPa) and the instantaneous plate velocity. The time-averaged power consumption was calculated by integrating the instantaneous power consumption over a definite time period.[8]

## RESULTS AND DISCUSSION

*Effects of operating conditions on gas holdup: gas–liquid systems*

The dependence of the gas holdup on the vibration intensity in the RPC filled with 2 % solutions of CMC PP 50 and CMC PP 200 at various superficial gas velocities is shown in Fig. 2. The gas holdup increases with increasing vibration intensity because of the contribution of the external energy to the process of bubble dispersion for vibration intensities higher than 5 cm/s. It is not possible to state with confidence how the gas holdup varies in the range of vibration intensity between 0 and 5 cm/s (dotted lines in Fig. 2). According to values of gas holdup at *Af* = 0, the gas holdup might decrease, remain constant or even slightly increase with increasing vibration intensity up to 5 cm/s. The same has already been observed in the case of water and Newtonian solutions.[8–16] At a constant vibration intensity, the gas holdup increases with increasing superficial gas vellocity, due to the increasing drag to gas flow through the plate holes, which is in accordance with recently published results.[19]
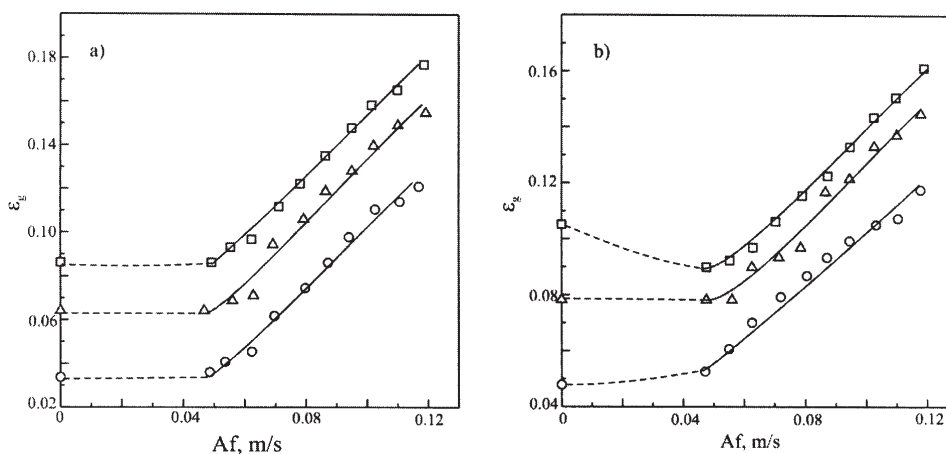


Fig. 2. Dependence of the gas holdup on the vibration intensity and superficial gas velocity for gas–liquid systems: a) CMC PP 50 and b) CMC PP 200 (solution concentration: 2 %; $u_g$, cm/s: 0.5 – circles; 1.0 – triangles; and 1.5 – squares).

The influence of the rheological properties of the liquid phase on the gas holdup in gas–liquid systems can be seen in Fig. 3, where the dependence of the gas holdup on the total power consumption (mechanisal agitation + aeration) at two superficial gas velocities is shown. In addition to the data for the CMC solutions, the variation of the gas holdup in the same RPC filled with a 69 % glycerol solution, which has Newtonian properties and a viscosity somewhat higher than that of the 2 % CMC PP 50 solution (Table II), is shown for the purpose of comparison. The gas holdup depends on the combined effects of the power consumption, the superficial gas velocity and the rheological properties of the liquid on the processes of bubble dispersion and coalescence, which occur in the interplate spaces. A difference was observed in the variation of the

gas holdup with increasing solution concentration of the two CMC at various superficial gas velocities. In the case of the CMC PP 50 solutions, at the same total power consumption and independently of the superficial gas velocity, the gas holdup decreased when the solution concentration increased, because coalesence of the bubbles is favored by increasing liquid viscosity (Fig. 3a and b). In case of the PP 200 CMC solutions, the same influence of the solution concentration was observed at higher superficial gas velocities (Fig. 3b): the gas holdup decreased with increasing concentration of the solution. However, at the lower superficial gas velocities (Fig. 3a), over the whole range of power consumption, the gas holdup for the 2 % CMC PP 200 solution was higher than that for the 1 % solution. The increase of gas holdup in the case of 2 % solution can be explained by the nature of the gas–liquid dispersion. In this system, the gas dispersion contains very small gas bubless with a low terminal rate, causing the gas holdup to increase in spite of the higher viscosity. The negative effect of viscosity can be seen by comparing the gas holdup for the two Newtonian liquids: the gas holdup was lower for the 69 % glycerol solution than for the CMC PP 50 solutions due to its higher visosity (Table II). Thus, at low superficial gas velocities, the gas dispersion is more efficient if the non-Newtonian liquid is more pseudoplastic, as in the case of the 2 % CMC PP 200 solution, compared to the 1 % solution (Table II).
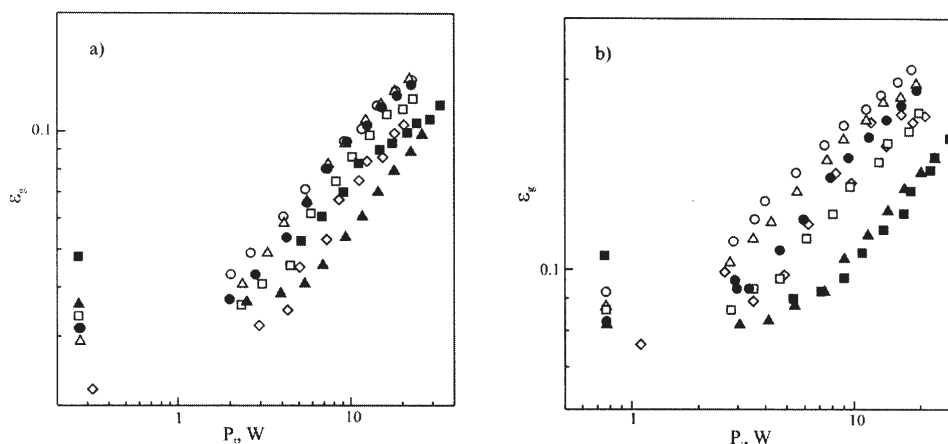


Fig. 3. Dependence of the gas holdup on the total power consumption and the rheological properties of the liquid phase for gas–liquid systems at superficial gas velocities of: a) 0.5 and b) 1.5 cm/s (solution concentration, %: 0.5 – circles; 1.0 – triangles; and 2.0 – squares; CMC PP 50 – open symbols; and CMC PP 200 – solid symbols; glycerol, 69 % – diamonds).

*Effects of the operating condtions on gas holdup: gas–liquid–solid systems*

The gas holdup in three-phase systems with a non-Newtonian liquid depends on the overall influence of the vibration intensity, the content of solid phase, the superficial gas velocity and the rheological properties of the liquid phase on the dispersion and coalescence of the gas bubbles.[19] The gas holdup increased with in-

creasing vibration intensity, superficial gas velocity and total power consumption (Fig. 4), which is in accordance with the observations for the two-phase system. By intensifying the mixing, the gas dispersion of the bubble is favored, and by increasing the aeration rate, the drag to the gas flow through the columns is increased, enhancing the gas holdup in the RPC.
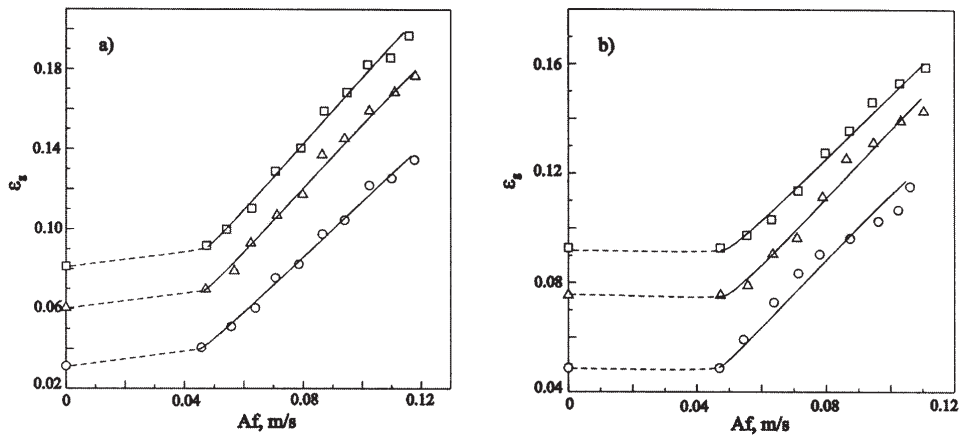


Fig. 4. Dependence of the gas holdup on the vibration intensity and the superficial gas velocity for gas–liquid–solid systems: a) CMC PP 50 and b) CMC PP 200 (solution concentration: 2 %; solids content: 3.84 % by volume; the symbols are the same as in Fig. 2).

The influence of the rheological properties of the liquid phase on the gas holdup in the three-phase RPC with a solids content of 6.61 % by volume is shown in Fig. 5. As in the two-phase system, the gas holdup in the RPC filled with CMC PP 50 solutions decreased with increasing liquid viscosity, *i.e.*, with increasing solution concentration. In he case of the CMC PP 200 solutions, the gas holdup depends on the combined influence of the rheological properties of the liquid phase, the mechanical mixing and the superficial gas velocity. At lower superficial gas velocities (0.5 and 1.0 cm/s), the gas holdup for the 2 % solution was unexpectedly higher than for the solutions of lower concentration, while at a superficial gas velocity of 1.5 cm/s, the gas holdup was the lowest in the case of the 2 % solution, as has already been noticed.[18] In three-phase systems with the 2 % CMC PP 200 solution, the gas holdup reaches a maximum value at a power consumption of approximately 15 W, and a further increase in the agitation intensity has no effect on the gas holdup. It can be speculated that the system reaches the maximum capability for bubble dispersion at a power consumption of 15 W, so that further intensification of mixing does not cause an increase of the gas holdup.

The influence of the solid phase on the gas holdup in the RPC is shown in Fig. 6. Solid particles placed in the interplate spaces intensify the bubble dispersion, hence the gas holdup in the three-phase system is greater than that in the corresponding two-phase one under the same operation conditions. The same has al-
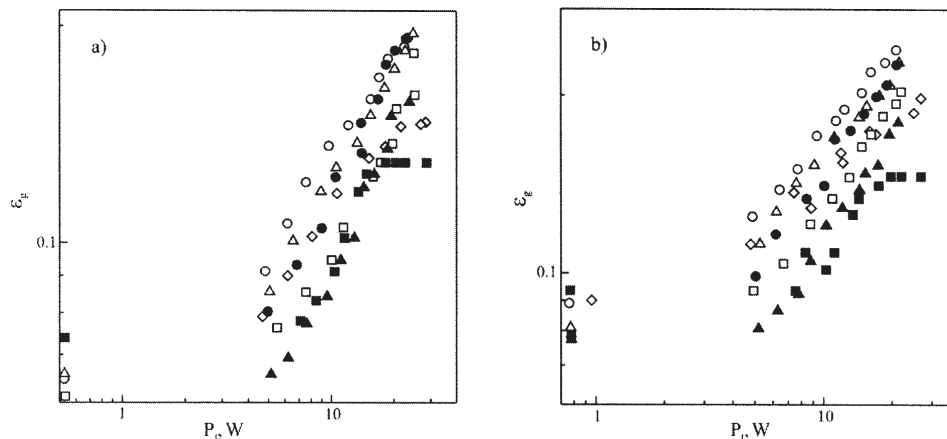
Fig. 5. Dependence of the gas holdup on the power consumption and the rheological properties of the liquid phase for gas–liquid–solid systems at superficial gas velocities of: a) 0.5 and b) 1.5 cm/s (solids content: 6.61 % by volume; the symbols are the same as in Fig. 2).

ready been noticed in RPCs of the same[19] or smaller (2.54 cm) diameter,[18] as well as in the presence of Raschig rings used as the solid phase.[23] The influence of the content of the solid phase in the range of 3.84 to 6.61 % by volume on the gas holdup depends on the superficial gas velocity. When the superficial gas velocity is lower, the gas holdup does not depend on the content of solid phase (Fig. 6a), while at higher superficial gas velocities the gas holdup is slightly higher if the content of solid phase is higher (Fig. 6b). The contribution of the spheres to the bubles dispersion at lower superficial gas velocities is probably the greatest at the smaller solids content (3.84 % by volume), hence increasing the solids content to 6.61 % by vol-
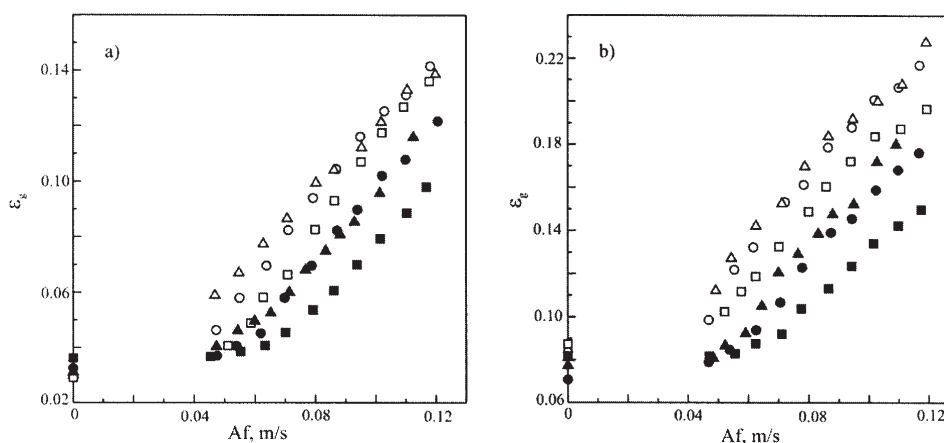


Fig. 6. Dependence of the gas holdup on the vibration intensity and the solids content for gas–liquid–solid systems at superficial gas velocities of: a) 0.5 and b) 1.5 cm/s (liquid: solutions of CMC PP 50 and CMC PP 200; solution concentration: 1 %; solids content, % by volume: 0 – squares; 3.84 – circles; and 6.61 – triangles; CMC PP 50 – open symbols; and CMC PP 200 – solid symbols).

ume does not result in an increase in the gas holdup. At higher superficial gas velocities, the larger number of spheres per interplate space contributes to the dispersion of the bubble to a higher degree, and, consequently, the gas holdup increases. The effect has already been noticed in RPCs filled with different liquids.[19]

*Gas holdup correlations*

The gas holdup in multiphase reactors with mechanical agitation is usually correlated with the power consumption and the superficial gas velocity. A summary of the empirical correlations for gas holdup in RPCs is given in Table III. The exponents of the power consumption and the superficial gas velocity are in the range from 0.2 to 0.495 and from 0.52 to 1.0, respectively, depending on the reactor geometry. By comparing the values of the exponents in the corresponding empirical correlations, it can be concluded that the influence of the power consumption on the gas holdup is greater, and that of the superficial gas velocity is lower in the column of larger diameter (9.2 cm) than in the column of smaller diameter (2.54 cm).

For the gas–liquid and gas–liquid–solid RPC filled with the CMC PP 50 solutions (Newtonian liquids), the gas holdup can be correlated with the power consumption (either the time-averaged or total) and the superficial gas velocity using the following equations, respectively:

$$\varepsilon_g = 0.053 P_{av}^{0.39} u_g^{0.605} \tag{1}$$

$$\varepsilon_g = 0.048 P_t^{0.42} u_g^{0.59} \tag{2}$$

(for 270 data entires, the mean relative deviations of the calculated values from the experimental ones were $\pm$ 10.57 and $\pm$ 10.58, respectively).

Similarly, the gas holdup in the gas–liquid and gas–liquid–solid RPC filled with the CMC PP 200 solutions (non-Newtonian liquids) can be correlated with the power consumption (either the time-averaged or total) and the superficial gas velocity using the following equations, respectively:

$$\varepsilon_g = 0.041 P_{av}^{0.40} u_g^{0.54} \tag{3}$$

$$\varepsilon_g = 0.038 P_t^{0.43} u_g^{0.52} \tag{4}$$

(mean relative deviations: $\pm$ 13.98 and $\pm$ 14.25, respectively, for 258 data entries). Equations (1) to (4) are valid for $Af > 4$ cm/s.

By analyzing Eqs. (1) to (4) it can be concluded that the exponent of the power consumption (0.39 to 0.43) does not depend on the rheological behavior of the liquid, while the exponent of the superficial gas velocity is lower for non-Newtonian liquids (0.54 and 0.52) than for Newtonian ones (0.605 and 0.59). Thus, the transfer of mechanical energy from the reciprocating plates to the system with respect to the gas holdup is equally efficient independently of the rheological behavior of the

liquid phase. On the other hand, the energy that the gas transfers to the system has a greater influence on the gas holdup in the case of Newtonian liquids. Independently of the rheological properties of the liquid phase, the exponent of the power consumption is less than that of the superficial gas velocity, which means that the intensity of aeration has a greater influence on the gas holdup than the mechanical agitation.

TABLE III. Empirical correlations for gas holdup in RPCs

| Column diameter/cm | Operating conditions | Correlation | Reference |
|---|---|---|---|
| 2.54 | Air–water | For $Af > 3$ cm/s | [8] |
| | $A = 1.2$–$2.5$ cm; $f = 1 - 7.2$ Hz | $\varepsilon_g = 6.2\,(P^*)^{0.2}u_g$ | |
| | $u_g = 0.4 - 1.5$ cm/s; $u_1 = 0$ cm/s | | |
| 9.2 | Air–water | For $Af > 4$ cm/s | [25] |
| | $A = 2.3$ cm; $f = 1 - 5$ Hz | $\varepsilon_g = 1.58\,(P^*)^{0.42}u_g^{0.92}$ | |
| | $u_g = 0.5 - 1.5$ cm/s; $u_1 = 0$ cm/s | | |
| 2.54 | Air–water–spheres | For $Af > 3$ cm/s | [24] |
| | $A = 1.2 - 2.35$ cm; $f = 1 - 7.2$ Hz | $\varepsilon_g = 2.515(P^*)^{0.29}u_g^{0..83}$ | |
| | $u_g = 0.4 - 1.5$ cm/s; $u_1 = 0$ cm/s | | |
| | $\varepsilon_S = 3.8$ and $6.2$ % by volume | | |
| 9.2 | Air–water–Rashig rings | For $Af > 3$ cm/s | [23] |
| | $A = 2.35$ cm; $f = 1 - 6$ Hz | $\varepsilon_g = 1.145P_{av}^{0.428}u_g^{0.662}$ | |
| | $u_g = 0.5 - 1.5$ cm/s; $u_1 = 0$ cm/s | $\varepsilon_g = 0.393(P^*)^{0.495}u_g^{0.628}$ | |
| | $\varepsilon_s = 0 - 0.32$ % vol. | $\varepsilon_g = 1.06P_t^{0.456}u_g^{0.663}$ | |
| 9.2 | Air–CMC PP 200 solutions-spheres | For $Af > 4$ cm/s | This work |
| | $A = 2.35$ cm; $f = 1 - 5$ Hz | $\varepsilon_g = 0.053P_{av}^{0.39}u_g^{0.605}$ | |
| | $u_g = 0.5 - 1.5$ cm/s; $u_1 = 0$ cm/s | $\varepsilon_g = 0.048P_t^{0.42}u_g^{0.59}$ | |
| | $\varepsilon_S = 9{,}3.84$ and $6.61$ % by volume | | |
| 9.2 | Air–CMC PP 200 solutions–spheres | For $Af > 4$ cm/s | This work |
| | $A = 2.35$ cm; $f = 1$–$5$ Hz | $\varepsilon_g = 0.041P_{av}^{0.40}u_g^{0.54}$ | |
| | $u_g = 0.5 - 1.5$ cm/s; $u_1 = 0$ cm/s | $\varepsilon_g = 0.038P_t^{0.43}u_g^{0.52}$ | |
| | $\varepsilon_S = 3.84$ and $6.61$ % by volume | | |

CONCLUSION

The gas holdup in a RPC is influenced by the vibration intensity, *i.e.*, power consumption, superficial gas velocity, solids content and rheological propeties of the liquid phase. By analyzing both two-phase and three-phase systems in the RPC, it can be concluded that the gas holdup increases with increasing vibration intensity and superficial gas velocity. With increasing concentration of CMC PP 50 solutions (Newtonian liquids), the gas holdup decreases, because bubble coalescence

is favored by the higher liquid viscosity. In the case of CMC PP 200 solutions (non-Newtonian liquids), the gas holdup depends on the combined influence of the rheological properties of the liquid phase, the mechanical agitation intensity and the aeration rate. The gas holdup in three-phase systems is greater than that in two-phase ones, the other operating conditions being the same, and increasing the solids content has little influence on the gas holdup, which depends on the superficial gas velocity.

## Symbols

$A$ – Vibration amplitude, m

$A_c$ – Reactor cross-section area, $m^2$

$Af$ – Vibration intensity, m/s

$D_c$ – Column diameter, m

$f$ – Frequency, Hz

$h_0$ – Dispersion height, m

$\Delta p^*$ – Maximum pressure variation at the bottom of the column, Pa

$P_a$ – Aeration power [$P_a = \rho_1 g h_0 (1 - \varepsilon_g) A_c u_g$], W

$P_{av}$ – Time-average power consumption, W

$P_t$ – Total power consumption, (= $P_{av} + P_a$), W

$P^*$ – Maximum power consumption ($A_c \Delta p^* u_{s,m}$), W

$u_g$ – Superficial gas velocity, cm/s

$u_1$ – Superficial liquid velocity, cm/s

$u_{s,m}$ – Maximum plate rate, m/s

$\varepsilon_g$ – Gas holdup, 1

$\varepsilon_s$ – Volume content of the solid phase, %

ИЗВОД

## УТИЦАЈ КОНЦЕНТРАЦИЈЕ РАСТВОРА И СТЕПЕНА ПОЛИМЕРИЗАЦИЈЕ КАРБОКСИМЕТИЛЦЕЛУЛОЗЕ НА САДРЖАЈ ГАСА У РЕАКТОРУ СА ВИБРАЦИОНОМ МЕШАЛИЦОМ

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У раду је испитиван садржај гаса у двофазним (гас–течност) и трофазним (гас–течност–чврста фаза) системима у реактору са вибрационом мешалицом (RPC), са растворима натријумове соли карбоксиметилцелулозе (CMC) различитог степена полимеризације (CMC PP 50 и CMC PP 200). Као чврста фаза коришћене су куглице од пропилена, а као гасовита фаза ваздух. Утврђен је утицај концентрације раствора и степена полимеризације CMC на садржај гаса у RPC при различитим оперативним условима. Садржај гаса у RPC зависи од интензитета вибрације, снаге утрошене за мешање дисперзије у колони, привидне брзине струјања гаса, удела чврсте фазе у колони и реолошких особина течне фазе. Са повећањем интензитета вибрације и

привидне брзине струјања гаса увећава се садржај гаса како у случају дво- (гас–течно-ст) тако и трофазног (гас–течност–чврсто) рада RPC. Са повећањем концентрације CMC PP 50 у раствору (Њутновски флуид) смањује се садржа гаса у RPC као последица коалесценције мехура у условима веће вискозности течне фазе, а у случају раствора CMC PP 200 (не-Њутновски флуид) садржај гаса у RPC зависи од утицаја реолошких особина течне фазе, интензитета вибрације и привидне брзине струјања гаса. Садржај гаса у трофазном је већи него у случају двофазног RPC при истим оперативним усло-вима али је утврђено да је утицај удела чврсте фазе на садржај гаса врло мали. Изведене су корелационе зависност које повезују садржај гаса са снагом утрошеном за дисперговање гаса у RPC и привидном брзином струјања гаса.

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