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A MATHEMATICAL MODEL FOR CALCULATING THE SATURATOR OF THE SUGAR PRODUCTION

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Abstract
Work on optimization of calculation process for the equipment intended for the absorption of carbon dioxide with the aim to neutralize calcium hydroxide when purifying crude juice in sugar production. Developed a mathematical model and parametric scheme to calculate the process of carbonation. Determined that the saturation with carbon dioxide of kiln gas negative impact on coefficient of its use. Was established that with the increase of CO2 in the gas efficiency of its use decreases.

Keywords: *optimization of calculation, purifying crude juice, sugar production*

Introduction

The main task of purifying crude juice by lime and kiln gas is to eliminate various non-sugar components to the maximum and to obtain deposits with high sedimentation and filtration rates.

Technological patterns of cold and heat treatment of hot crude juice that became the most prevalent in industrial practice, include predefecation as well as combined cold or mild hot primary defecation.

Thus, high quality of intermediate products is achieved due to the presence of cold (warm) stage of primary defecation, which leads to the increase of lime solubility under temperature decrease of sugar containing solution, accompanied by the dissolution reaction of reducing substances towards the formation of little colored substances. The latter being well absorbed in the process of I saturation, where the intense decomposition of chromophoric systems and dye molecules with a simultaneous decrease of colouration takes place, while heating of cold crude juice, as a result of reduction of lime solubility,is accompanied by the formation of a supersaturated sugar lime liquid, which under further saturation undergoes the gel phase, possessing high absorption properties.

But cleansing crude juice on the circuit with cold (warm) - main hot defecation is not always achieved both high quality and sedimentation and filtration performance.

One radical methods to improve the filtration-sedimentation properties of deposit – before carbonation treatment. Therefore, in industrial practice, especially in foreign countries, were spread purification and where to get sludge with good sedimentation, filtration properties used pre-defecosaturation or previous defecation in combination with pre-defecosaturation. As a result of macromolecular substances and substance coagulated colloidal dispersion with simultaneous dehydration and adsorbed on the surface of the formed crystals of calcium carbonate.

Promising ways of refining crude juice both in terms of the maximum effect for purifying and forming good filtration sedimentation properties of deposit are referred to the separation schemes of bulk coagulates from non-sugar components prior to primary defecation. An improved treatment is based on the exclusion of deposit dissolution in the process of primary defecation and improved efficiency of I saturation on the pure deposit of calcium carbonate.

At sugar plants it is recommended to put into a widespread practice the scheme of crude juice defecation with progressive pre-defecation, combined primary defecation, defecation before the second saturation phase with recirculation of condensed suspension of II saturation along with the part of unfiltered juice of the I saturation for pre-defecation.

Materials and Methods

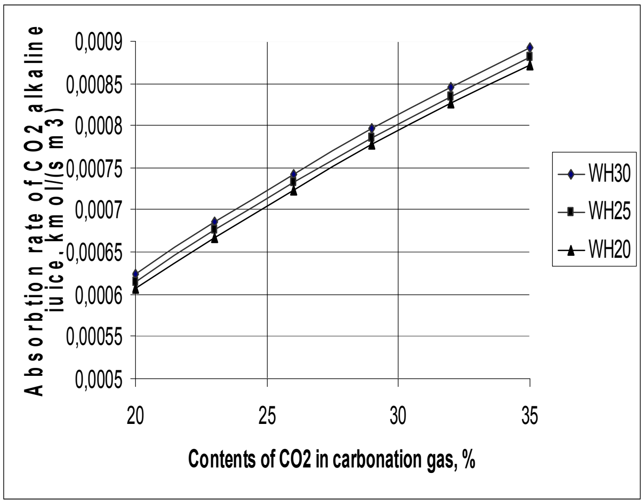
The authors has done work on optimization of calculation process for the equipment intended for the absorption of carbon dioxide with the aim to neutralize calcium hydroxide when purifying crude juice in sugar production.

For this purpose there was developed a mathematical model to calculate the process of carbonation (fig. 1). The first saturation involving calcium carbonate completes the formation of deposit with the required for its isolation sedimentation and filtration properties.

On the amount of juice extracted from the first carbonation non-sugar components adsorption and co-crystallization along with the cost of lime significantly affect the following parameters:

- the content of calcium hydroxide in the juice during the crystallization of calcium carbonate;
- temperature;

- the rate of absorption of carbon dioxide;
- surface area and the amount of the charge particles of calcium carbonate;
- linear velocity of crystallization of calcium carbonate and others.



Figures 2. Dependence of the rate of absorption of CO2 from CO2 in the gas and the diameter of the apparatus (WH30 – 3 m; WH25 – 2,5 m; WH20 – 2 m).

High index of the degree of utilization of carbon dioxide provides the plant without overspending limestone, fuel and energy, significantly improves control of the first carbonation. The degree of use of carbon dioxide affect the following parameters:

- the content of calcium hydroxide in the juice that contained in saturator;
- the interface between the juice and gas;
- the intensity of mixing juice and others.

The ultimate goal of this work is to achieve the optimal value saturator diameter depending on the content of carbon dioxide in carbonation gas.

Results

It was established that at low content of carbon dioxide in the carbonation gas up to 20% degree of absorption increases to about 70%.

When optimizing the relationship was taken into account the above process parameters and made reference calculation. For tabular data obtained equations used in the model [1].

This value Henry constant for temperatures in the range 20 – 90 °C, which is determined by a formula obtained by least squares with absolute accuracy, which is $\delta^2 = 1,6 \cdot 10^{-2}$

$$He = 1,654 \cdot 10^{-4} t^2 - 9,162 \cdot 10^{-3} t + 0,157 \,, \qquad (1)$$

amount of weight the partial pressure of water vapor, which is determined from the equation that obtained with absolute accuracy $\delta^2 = 4.818 \cdot 10^{-3}$

$$P = 2,48 \cdot 10^{-4} t^2 - 2,0613 \cdot 10^{-2} t + 0,5252 \,, \qquad (2)$$

and the value of the dynamic viscosity of the juice, which is obtained by approximated with the mean square error $\delta^2 = 5,38 \cdot 10^{-10}$ formula

$$\mu = 2 \cdot 10^{-7} t^2 - 3,8 \cdot 10^{-5} t + 2,27 \cdot 10^{-3} \,. \qquad (3)$$

Conclusion

Resulted in a determination that the theoretical size saturator lower than those devices that are used in the sugar factories and varies from 2,5 to 2,1 meters with increasing content of carbon dioxide gas in carbonation. Saturation with carbon dioxide of the kiln gas negative impact on rate of its use. With the increase of CO2 in the gas twice the efficiency of its use is reduced by 25% (fig. 2) [2].

References

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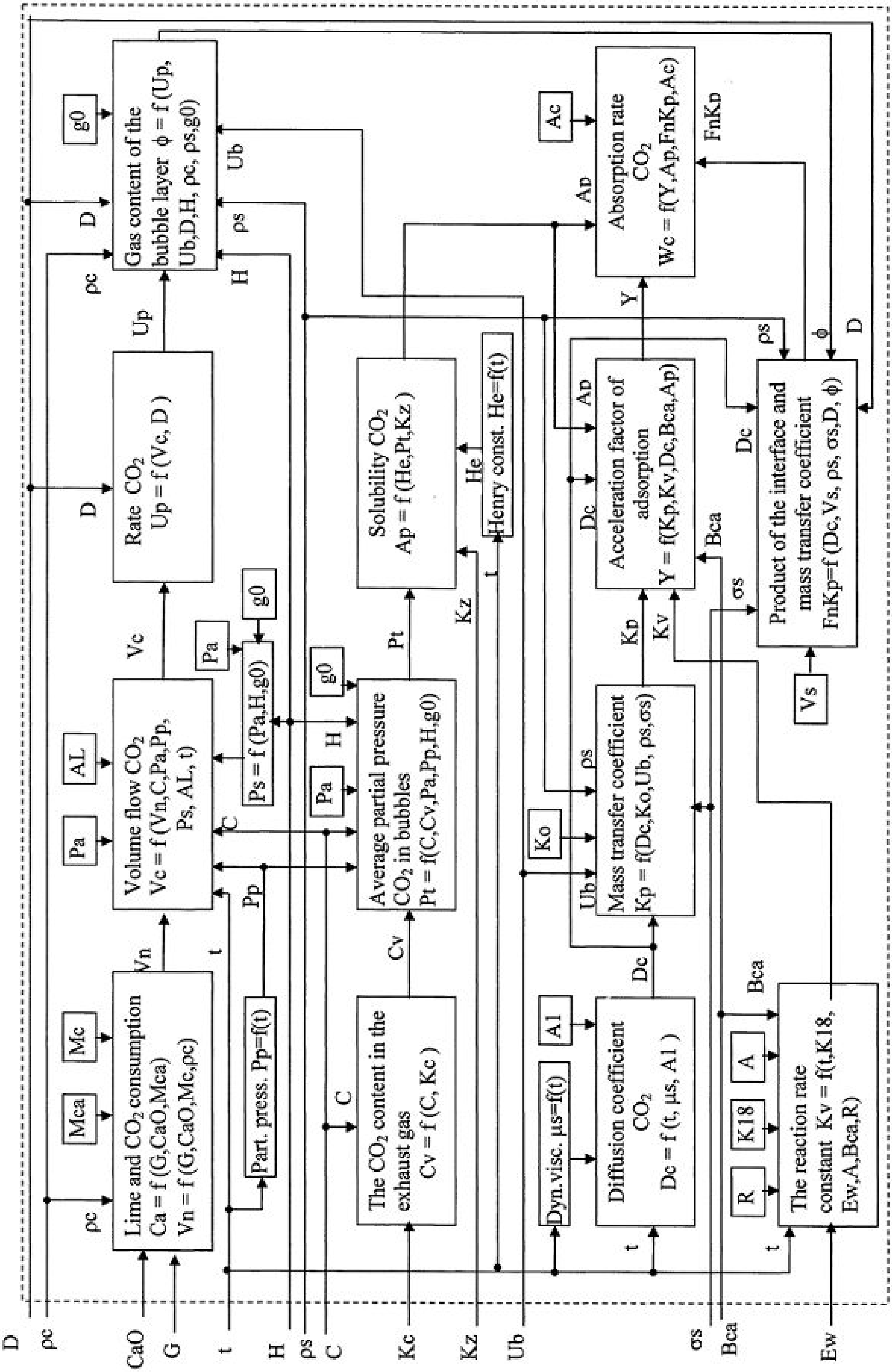

Figures 1. Parametric diagram of mathematical model for calculating the rate of absorption of CO_2 in the saturator