Dissolution of solid polydisperse materials during pneumatic mixing

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The thesis investigates dissolution of solid polydisperse materials during pneumatic mixing. In particular, a study of kinetics regularities of dissolution of C_6H_5COOH in water. The methods of experimentations are described. It has been experimentally established that with increasing air flow, the duration of the dissolution process is reduced. The influence of mixing applications on the dissolution process is described. The advantages of the dissolution process during the pneumatic mixing of the solution are analyzed.

Keywords: dissolution, pneumatic mixing, benzoic acid, polydisperse phase, mixing applications.

I. Analysis of recent research and publications

The dissolution belongs to one of the most widely used mass transfer processes, which are widely used in industry. It is known that the investigation of the dissolution process is thoroughly investigated, mainly for single particles of spherical form [1]. The main attention during the study of the dissolution of single particles was given to determining the coefficient of mass transfer experimentally and the presentation of experimental data theoretically by the method of generalized variables. In particular, the dissolution of single particles of benzoic acid in a spherical form is also described in Garner and Hoffmann's work [5].

In spite of the fact that the study of the dissolution of single particles has been given a lot of attention by different researchers, the industry usually dissolves polydisperse systems consisting of many particles of irregular shape. The dissolution in a layer of solid material is given in works [6-7]. Dissolution is a transition phase to a solid solution and can be accompanied by the complete disappearance of the solid phase. Dissolution is a complex process that can occur in diffusion, kinetic or mixed areas. Widespread use of dissolving was determined in halurhiya during the process of natural salts refinery [2].

Reducing costs associated with the intensification of the process of dissolution. There are many ways of intensification of this process, mechanical and pneumatic mixing, creating a fluidized bed, ripple motion of fluid, cavitation and ultrasound sparks [3]. A known method for intensifying reaction and mass transfer processes in heterogeneous systems is realized in a device for dissolving solid particles in a liquid in which a liquid carrying solid particles moves along a pipe having a variable cross section throughout its length [4]. However, the disadvantage of this method is the large dimensions of the installation, loss of pressure in the variable cross sections, and also possible erosion of the walls of the pipe.

Most of the methods of intensification characterized by high energy costs, flexible design of mixing devices, so we investigated the method by intensifying creation the pneumatic mixing in the device with compressed air.

In the technological process, the concentration of the target component should be high and approach to the concentration of saturation.

Therefore, the study and establishment of the laws of the process of dissolution of polydisperse mixtures is an urgent task.

II. The aim of the work

The aim is to study the kinetics of dissolution process of polydisperse solid phase of benzoic acid in water during the air mixing and described the influence of mixing applications on the dissolution process .

III. Experimental study and its analysis.

Experimental study of dissolution polydisperse solid phase was conducted in a pneumatic stirring apparatus.

To carry out the dissolution process, the apparatus for pneumatic mixing was filled with distilled water, where the initial concentration of acid was $C_0 = 0$. The compressor was switched on. The regulator was exposed to the required pressure and air flow rate. The acid was lit and the stopwatch was switched on too.

We analyzed the process on the following parameters. Concentration of saturation C = 2.63 g/l. The volume of the solution was V = 1.5 l. The weight of benzoic acid (BA) in the experiments was m = 4.5 g. The average size of the fraction was d = 1.5 mm. The air consumption was also unchanged and was $V = 2.67\ m^3/h$. Ambient temperature was 15 ± 0,5 C.

Through samplers were taken 5 ml of the analyzed solution at intervals of 10 minutes until completion of the dissolution process. The dissolved C_m content was determined from the titrimetric analysis by titrating the sample with a 0.01-normal solution of NaOH in the presence of a phenolphthalein indicator.

On the basis of the calculated data, the dependence of the change of the concentration of benzoic acid in the solution from the time C = f (τ), which is presented in Fig. 1:

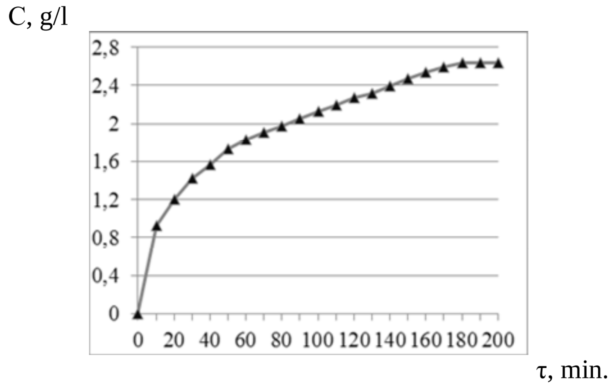

Fig.1 The dependence of the concentration of benzoic acid on the duration of the dissolution process.

The main disadvantage of the dissolution process when pneumatically stirred is the formation of foam, which is accompanied by the removal of solid particles of the soluble material outside the zone of intensive mass transfer and, thus, increasing the duration of the dissolution process to a given concentration.

The kinetics of the dissolution process is determined by the speed of reaching the concentration of saturation by the target component. We investigated the influence of solid particles of various forms, made from chemically inert to benzoic acid materials, on the pneumatic mixing process and, accordingly, on the kinetics of dissolution of benzoic acid in water. This influence is shown in Figure 2.

The amount of the introduction of mixing solutions in the solution should be as small as possible to exclude their effect on the dissolution of polydisperse particles, but only to prevent the rendering of the solid phase in the foam.

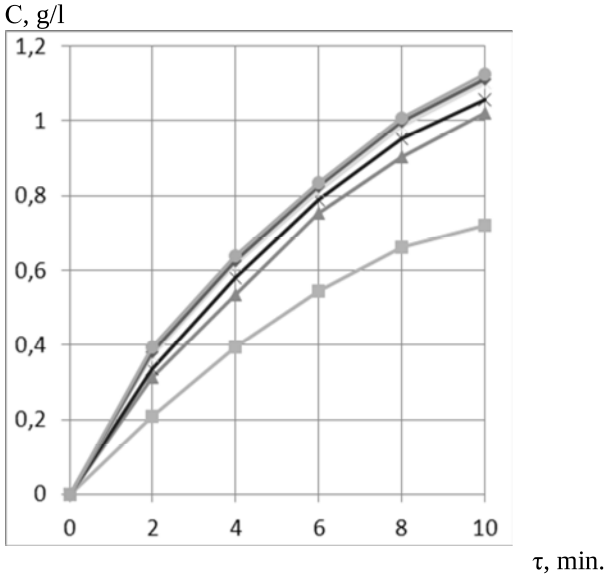

Fig.2 Effect of the number of mixing balls on the kinetics of the dissolution process.
■- M_b=0 g; ▲- M_b=12.9 g; **x**- M_b=37.4 g; ♦- M_b=70 g; ●- M_b=100 g.

As a result of experimental studies it was found that the addition of chemically inert balls significantly improves the kinetics of the dissolution process, reducing its duration and, accordingly, energy consumption. The addition of mixing balls prevents the solid phase from solids from the zone of intense mass transfer to the foam layer, there by providing continuous washing of particles with water, increasing the surface of the mass return.

We also investigated the effect of increasing the air flow rate on the speed. It is established that the increase in air flow rate above 4.5 m^3/h significantly increases the foam height, which hovers about 80% of solid particles, which negatively affects the dissolution intensity, reducing the size of the zone of intensive mass transfer. That's why, this air flow was the limit in our research.

The choice of the dissolution process when pneumatically stirred is due to a number of advantages over other methods. Pneumatic mixing devices have a simplified internal construction, since they don't have mixing devices. The absence of these devices eliminates the need for their maintenance, as well as prevents contamination of the target product, eliminating the possibility of reaction between the material of the mixing device and the solution, which is very important in the food and pharmaceutical industry. The use of bubbling air provides a constant temperature of the solution, bringing out the heat released during dissolution, outside, with the bubbles. The main advantage of using such mixing is the uniform and intense mass transfer between the solid phase and the liquid. The simple design of pneumatic mixing machines allows you to significantly reduce the cost of their service.

Conclusions

The dissolution of polydispersed benzoic acid particles in a pneumatic mixing apparatus has been experimentally investigated. The dissolution of polydispersed benzoic acid particles in a pneumatic mixing machine has been experimentally investigated. The method of conducting experiments is described. The dependence of the mass concentration of the dissolved substance on the duration of the process and the plot is constructed. The influence of the side effect of foam formation on the dissolution process is considered. The influence of inert mixing applications on the process of pneumatic dissolution is established and we have also built graphical dependence of the effect of the number of mixing balls on the kinetics of the dissolution process. It has been experimentally established that with increasing air flow, the duration of the dissolution process is reduced. The advantages of the dissolution process during the pneumatic mixing of the solution are analyzed.

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