Investigation of the condition of non-stationary process during the dissolution of a set layer of granular material

Oksana Liuta[1], Dmytro Simak[2]

1. National University "Lviv Polytechnic", Ukraine, Lviv, St.Bandera street, 12
oksana.lyuta@gmail.com
2. Sumy State University, Ukraine, Symu, Rimsky-Korsakov street 2.

The dissolution of a stationary set layer of a granular material was investigated. The method of experimental research of dissolution was presented, the coefficient of mass deducing, the value of which was used during the analysis of dissolution of the layer, was determined. The change in concentration over the height of the layer, depending on the time, was theoretically determined.

Keywords: granular material, dissolution, filtration, layer.

The dissolution of solid substances in industry is realized by various methods: dissolution in a device with mechanical or pneumatic mixing, in devices with a fluidized bed of granular material, in auger solvents and devices with set and moving solid phase. The latter method is called dissolution in the stationary layer, through which the liquid phase is filtered. The dissolution of solid substances by filtration through a layer of granular material is realized in the natural environment during precipitation. Water with dissolved salt in it is collected in underground storage facilities and is used for water supply needs of the population. The mathematical models of dissolution presented in the literature refer to stationary or quasi-stationary processes in a layer of granular material. In reality, the initial stage of dissolution is always non-stationary and the nature of the change in the size of the particles over the height does not correspond to the stationary dissolution process.

Experimental researches in a layer were conducted in a glass column, which in the bottom part contains a grid, which was filled with a fraction of sodium chloride salt. Distilled water was supplied from above and its flow was regulated by a crane. After passing the column, the liquid was collected in a measuring cup. In the first series of experiments, the coefficient of mass deducing during the dissolution of a solid substance in the stationary layer was experimentally determined and its comparison with the theoretical values calculated according to the criterion equations was carried out. The value of the coefficient of mass deducing β was determined according to the dependence representing the averaged value on the height of the layer, and was equated to the theoretical value determined according to the criterion equations. The determined value of the coefficient of mass deducing on the basis of experimental data is $1{,}34\cdot10^{-5}$ m/s, and the theoretical - $2{,}12\cdot10^{-5}$ m/s, which is explained by the fact that the particles that are in the layer contact with each other and this surface does not take part in mass transfer.

The calculation of non-stationary dissolution of the stationary layer is presented. The height of the layer was divided into separate layers, each of which was equal to the initial diameter of the salt particles. The initial condition was the zero concentration of liquid entering the upper layer of the granular material. The kinetics equation of the dissolution was used and the time of complete dissolution of the upper layer of particles T_S was determined.

Dividing the mass on the volume of the liquid, which contacts with the first layer, we determine the average concentration that leaves the first layer and is the initial concentration for the second layer c_1. For any i-th layer, which is multiple to the initial particle diameter, the time of its complete dissolution τ_i will be greater than the T_S due to the reduction of impellent of the process.

Graphical dependence of the relative diameter of solid particles on the height of the layer is presented. Altitude is measured on top of the device. The calculation data are given for the time of complete dissolution of the upper layer, which for the conditions of the experiment is 322 seconds.

[1]. Иванов Е.В. Влияние нестационарных еффектов на скорость растворения одиночной частицы. ТОХТ. - 2013. т.47, №6, с. 624 — 629.
[2]. Symak, D.M., Liuta, O.V. (2015). Nestatsionarnyi protses rozchynennia sharu zernystoho materialu. Khimiia, tekhnolohiia rechovyn ta yikh zastosuvannia, 812, 308–312.
[3]. Натареев С.В., Кокина Н.Р., Натареев О.С., Дубкова Е.А. Массоперенос в системе с твердым телом. - 2015. т.49, №1, с. 74 — 78.