UDC 66.021.3

R.I. Lankin, Assistant Lecturer;
V.S. Frantskevich, Head of the Department, PhD (Engineering),
(BSTU, Minsk);
Su Hailong, Master's degree student;
Liu Xinyu, Master's degree student
(BSTU, Minsk, China)

INFLUENCE OF THE GEOMETRY OF THE ELEMENT OF THE MOVABLE PACKING ON MASS TRANSFER

Mass transfer processes are important in various industries where it is necessary to effectively clean gas emissions and control dust content in the atmosphere. One of the key components determining the efficiency of these processes are the elements of the moving packing, which ensure optimal interaction between the gas and liquid phases. The geometry of these elements is critically important, since it affects the hydrodynamics and, therefore, the intensity of mass transfer [1].

As shown in studies, moving packings are able to adapt to various operating conditions, providing minimal hydraulic resistance and efficient liquid distribution. This is especially important in conditions where there are liquids prone to foaming, or in systems with high liquid : gas ratios. A variety of packing shapes and designs allows designing systems that perform cleaning and absorption tasks with maximum efficiency [2, 3].

Studies show that correctly selected geometric parameters of moving packing elements can significantly increase the efficiency of mass transfer. For example, the presence of "dimples" on the surface of the packing can increase the total contact area between the phases, which promotes more intense interaction and increases the mass transfer coefficient. However, it is important to consider that changes in geometry can also affect hydraulic resistance, which requires careful optimization of designs [4, 5].

This paper examines the effect of the geometry of moving packing elements on mass transfer processes. Experimental studies using various packing shapes, including smooth balls and elements with an offset center of gravity, will be analyzed. The main focus is on how changes in geometry affect hydraulic resistance and the overall efficiency of mass transfer processes [5, 6].

The purpose of this study is to identify the optimal geometric parameters of moving packing elements that will improve the efficiency of absorption processes. The results can be useful for further development and optimization of technologies related to the purification of gases and liquids, which, in turn, helps to improve the environmental situation and reduce the negative impact on the environment. The experimental setup (Fig. 1) is an absorption column made of organic glass, which allows visual monitoring of the processes occurring inside the apparatus [1]. This design allows researchers to observe the dynamics of the interaction of the gas and liquid phases, as well as the distribution of the packing and liquid flow.

The absorber includes the following components:

– Column – a tube in which the mass transfer process occurs;

– Support and distribution plate – supports the packing elements and distributes the liquid;

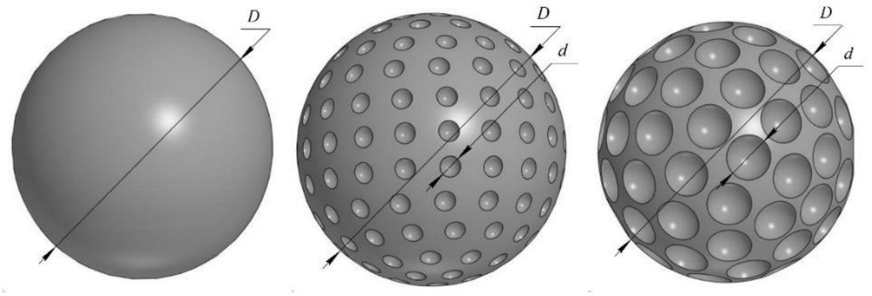
– Limiting plate – prevents packing from being carried away from the apparatus;

– Fan – ensures the supply of the gas phase (air) to the column;

– Diaphragm and rotameter – used to measure the flow rate of liquid and gas;

– U-shaped differential pressure gauge – records the pressure drop in the column.

Various types of packing (Fig. 1, 2) [1] were designed and manufactured for the experiments, each of which has a unique geometry, which allows us to study their effect on the efficiency of mass transfer in the absorption column.



a b c

Figure 1 – Spherical packing balls:
a – smooth sphere; b – sphere with diameter ratio d/D = 0.075;
c – sphere with diameter ratio d/D = 0.225

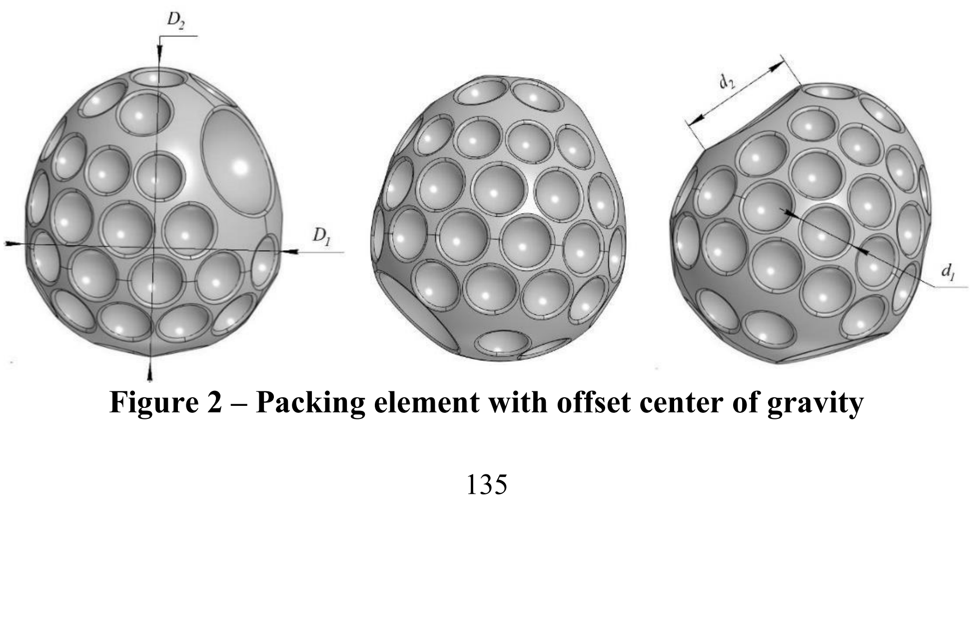


Figure 2 – Packing element with offset center of gravity

All the packings were manufactured using modern technologies such as 3D printing, which ensured high accuracy and uniformity of their sizes and shapes. This minimizes deviations in experimental data and increases the reliability of the results.

In the course of laboratory studies on mass transfer, there is always a need to select a model medium that includes gas and liquid phases. The components of this medium must be easily accessible, safe and non-aggressive for researchers. The key point is that the results obtained under such conditions must be relevant and applicable for assessing the operation of industrial mass transfer devices with real substances. For this work, a model medium for CO_2 desorption from water was selected. The efficiency of mass transfer, expressing the degree of equilibrium achieved during carbon dioxide desorption, is determined by the liquid phase – E_l [7].

The initial and final acidity of the aqueous solution was determined using a pH-meter. Then, using a well-known formula, the pH data were converted into concentration. After that, a graph of the dependence of these data on the time of the experiment was plotted (Fig. 3).

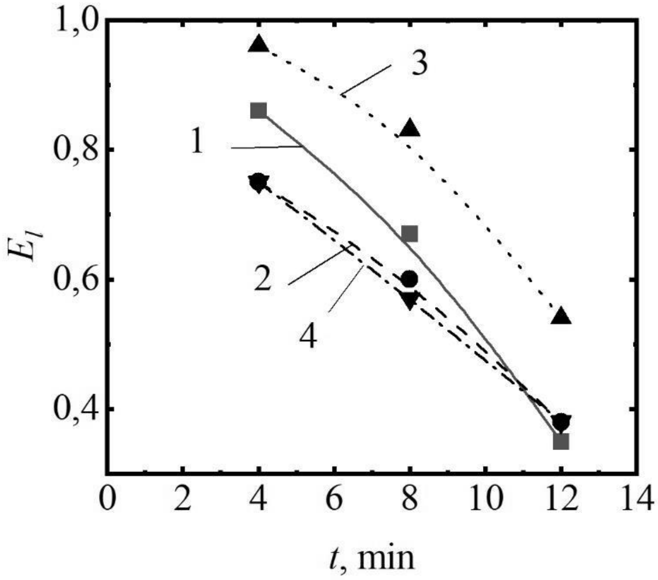


Figure 3 – Efficiency over time: 1 – type 1; 2 – type 2; 3 – type 3; 4 – type 4

The plot (Fig. 3) shows that the efficiency of type 3 packing is higher compared to other types of packing. This is explained by the increased mass transfer surface, which promotes more intense contact between the gas and liquid phases. The increased surface area allows a larger number of molecules to interact, which significantly increases the rate of absorption or desorption processes.

The plot shows how the efficiency (*E*□) changes depending on time (*t*), which allows us to trace the dynamics of changes in mass transfer processes. There is a tendency for efficiency to decrease with increasing time, which may indicate that the system is approaching equilibrium. This behavior is typical of many mass transfer processes, where at the beginning there is an active interaction of components, and as equilibrium is reached, the efficiency begins to decrease.

Thus, the results presented in the graph emphasize the importance of choosing the packing and experimental conditions to achieve maximum efficiency of mass transfer processes. These data can be useful in designing new devices and optimizing existing technologies in the chemical and petrochemical industries.

LITERATURE

1. Ланкин, Р.И., Францкевич В.С. Влияние геометрических параметров опорно-распределительных решеток на гидродинамику в массообменном аппарате с подвижной шаровой насадкой / Вестник Полоцкого государственного университета. Серия В, Промышленность. Прикладные науки. – 2023. – № 2. – С. 108–112. DOI 10.52928/2070-1616-2023-48-2-108-112.
2. Заминян, А.А. Абсорберы с подвижной насадкой / А.А Заминян., В.М Рамм. – М.: Химия, 1980. – 184 с.
3. Ланкин Р.И., Францкевич В.С. Гидравлическое сопротивление абсорбера с подвижной шаровой насадкой / Труды БГТУ. Сер. 2, Хим. технологии, биотехнология, геоэкология. – 2022. – № 2 (259). – С. 107–114.
4. Maćkowiak, J. Fluid Dynamics of Packed Columns. Principles of the Fluid Dynamic Design of Columns for Gas/Liquid and Liquid/Liquid Systems / J. Maćkowiak. – Heidelberg: Springer-Verlag, 2010. – 355 p.
5. Левш, И.П. Тарельчатые абсорберы и скрубберы с псевдоожиженным (подвижным) слоем орошаемой насадки / И.П. Левш, А.К. Убайдуллаев. Ташкент: Узбекистан, 1981. – 236 с.
6. Балабеков, О.С. Расчет и конструирование тепломассообменных и пылеулавливающих аппаратов с подвижной и регулярной насадкой: монография / О.С. Балабеков, А.А. Волненко. Шимкент: GOLDYES, 2015. – 184 с.
7. Рамм, В.М. Абсорбция газов. 2-е Изд., переработ. и доп. / В.М. Рамм. – М.: Химия, 1976. – 656 с.