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INTENSIFICATION OF MASS TRANSFER IN PACKED COLUMN APPARATUSES

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Abstract
This article analyzes the mass transfer processes carried out in packed column apparatuses and methods for their intensification. Packed columns are widely used in the chemical industry for separation, purification, and processing of substances. These devices increase the efficiency of mass transfer by expanding the contact surface between the gas and liquid phases through nozzles located inside them. The article also covers the shape and material of fittings, optimization of working parameters, intensification mechanisms through additional technologies (ultrasound, pulsation, electromagnetic field) and new generation fittings.

Keywords: Packing column, mass transfer, intensification, chemical industry, gas-liquid system, packing, technological parameters, efficiency, environmental safety, innovative approaches.

Introduction

A packed column is a cylindrical apparatus, the inner part of which is filled with special bodies of various shapes and sizes, i.e., packing, which serves to carry out metabolic processes. In this apparatus, the nozzles form a multiphase contact surface during the interaction of liquid and gas flows, which significantly increases the efficiency of the exchange process. Nozzles can vary in shape and material: for example, ring nozzles (Rashig, Pall, Berl rings), spherical (i.e., ball-shaped) nozzles, as well as star-shaped, branched, or spiral types. These fittings are made of plastic, ceramic, or metal materials, and each type has its own technological advantages.

Intensification of mass transfer in packed column apparatuses is an important direction aimed at increasing the efficiency of mass transfer between liquid and gas phases in the chemical industry and technological processes. Such devices are widely used in such processes as separation, purification, washing, absorption, and distillation. Mass exchange is a physicochemical process occurring between two or more phases through the transition of components from one phase to another.

This process often occurs between gas and liquid phases and is widely used in industrial technologies, especially in the fields of chemistry, petrochemistry, pharmaceuticals, and

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environmental protection. In attached column apparatuses, the mass transfer process is carried out through streams organized in a vertical direction. That is, the gas phase moves upwards from the lower part of the apparatus, and the liquid flows downwards from the top of the column. The nozzles inside the column ensure intensive contact between the gas and liquid. The nozzles divide the liquid into small particles, and the gas, colliding with these particles, transfers the components contained in it into the liquid or vice versa. In this case, substance exchange occurs, i.e., a certain substance in the gas dissolves in the liquid or the substance in the liquid transitions into the gas. The constant contact between these two phases, the large surface areas, and the opposite direction between the flows increase the speed and efficiency of mass transfer. In this way, the necessary technological results are achieved in the packed columns.

Intensification of mass transfer is a set of methods aimed at making the process more efficient and faster. In attached column apparatuses, such intensification is achieved through several important factors. One of them is the shape and material of the packing. To achieve high efficiency, fittings with a wide surface, many holes, effectively retaining liquid and gas, but with low flow resistance, are selected. Such nozzles increase the surface area of mass transfer and enhance interfacial contact.

Optimization of working parameters also plays an important role. The intensity of the process is increased by adjusting such indicators as liquid and gas flow rate, temperature, pressure, and flow rate in accordance with the technological regime. For example, by increasing the flow rate of liquid or maintaining a steady gas flow, a stable contact surface is created between the phases.

In addition, additional technological approaches are also of great importance. With the help of ultrasonic vibrations, liquid particles are crushed, and their contact area with the gas increases. With the help of pulsation technology, the flows in the column are vibrated, which activates the movement of substances. Also, using electromagnetic fields, the movement of certain substances is directed or accelerated. Sometimes the column itself is set in motion, i.e., the packed column operates in a rotating or oscillating position, which positively affects mass transfer.

Another modern approach is the use of a new generation of nozzles. Such nozzles are designed as multi-layered based on microstructures and provide a very large contact surface. In addition, nozzles of individual designs, manufactured using 3D-printer technology, are developed in accordance with each technological need. Such innovative nozzles provide greater efficiency and economy compared to conventional types. Thus, the mass transfer process becomes intensive, stable, and energy-efficient. Intensified mass transfer in packed column apparatuses is widely used in various industries and serves to significantly increase their technological efficiency.

First of all, these devices play a key role in the chemical and petrochemical industries. For example, in the processes of producing methanol, ammonium, and gasoline, the rate and quality of substance exchange between the gas and liquid phases directly affect the final properties of the product. Especially in methanol synthesis, the effective operation

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of packed columns at the stages of separation and purification of reaction products determines the production capacity.

In the pharmaceutical industry, packed columns are used in the processes of separation, purification, and crystallization of medicinal substances. High accuracy and cleanliness are required in this area, therefore the efficiency of mass transfer is very important. With the help of these devices, it is possible to isolate the necessary active substances from the components dissolved in the liquid phase. Such columns are also widely used in the food industry, especially in the processes of separating and purifying alcoholic products, such as ethanol. These processes are carried out on the basis of distillation or rectification, and due to intensive mass transfer, the quality of the product and the degree of separation are high.

In the field of environmental protection, packed columns are an important tool for cleaning industrial waste, in particular gases. By washing exhaust gases, i.e., extracting harmful components from them, it is possible to ensure environmental safety. Atmospheric emissions are reduced by bringing gas into contact with a liquid and dissolving harmful gaseous substances from it. Thus, nozzle column apparatuses are of great importance not only in economics, but also in ecological terms in various industries. In recent years, the chemical industry of Uzbekistan has been fundamentally modernized, and within the framework of this process, the efficiency of modern technologies, including packed column apparatuses, is being increased.

At large manufacturing enterprises, in particular at such industrial giants as "Navoiazot" and "Ferganaazot," advanced equipment has been introduced, and existing technological lines have been updated. At these enterprises, the efficiency of mass transfer processes carried out in the gas and liquid phases using packed columns is brought to a high level.

Updated nozzles play an important role in reducing energy and raw material consumption, improving product quality, and stabilizing the production process. These apparatuses are equipped with modern high-level nozzles, which serve to expand the contact surface, optimize the movement of flows, and accelerate interphase mass transfer. This, in turn, increases the overall efficiency of the process and reduces the amount of waste.

Especially today, when the issue of environmental safety is relevant, special attention is paid to reducing the harm of technological processes to the environment in Uzbekistan's industrial policy. Therefore, the use of a new generation of packing devices leads to effective cleaning of industrial waste and a significant reduction in the volume of harmful substances released into the atmosphere. In addition, these technologies serve as an economically beneficial solution for enterprises, optimizing energy costs in production. Research institutions and technical universities of Uzbekistan are also actively conducting research in this area. Students and specialists are developing new types of nozzles, testing their effectiveness under experimental conditions, and studying the possibilities of their industrial application. This, in turn, serves to strengthen the country's technological independence and innovative potential.

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In conclusion, the intensification of mass transfer in packed column apparatuses plays an important role in increasing the efficiency of the modern chemical industry. With the help of correctly selected nozzle shape, optimal operating parameters, and additional technological methods, the speed and accuracy of the process are significantly improved. In the context of Uzbekistan, the modernization of these devices is relevant not only from the point of view of economic benefits, but also from the point of view of ensuring environmental safety. Therefore, the implementation of scientific research and technological innovations will serve to increase competitiveness in the industry.

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