units in that the packing elements are in a suspended state and perform chaotic and pulsating movements. The units are used in industry, in particular in the production of mineral fertilizers and in non-ferrous metallurgy. These absorbers can operate under high loads on the gas phase (gas velocity on the full cross-section of the absorber is about 2.5–5.0 m/s), are characterized by high efficiency and have an important property: the movement of the packed bodies practically eliminates the possibility of clogging with sediments [5].

In conclusion, movable packing significantly influences flow dynamics in absorption systems and highlights the advantages of movable packing in absorption systems, particularly its improved mass transfer efficiency and flow uniformity, despite the trade-off of increased pressure drop. As the packed tower is mainly composed of the tower frame, packing, and various accessories, its design plays a crucial role in the overall performance. Future research should focus on optimizing packing designs and exploring long-term operational impacts to further enhance the effectiveness of absorption technologies.

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APPLICATION OF FLUID DYNAMICS OF MOVABLE BALL PACKING IN MASS TRANSFER DEVICES

In today's industrial world, the efficient operation of mass transfer devices is crucial for many production processes. The emergence of movable ball packing has brought new vitality to mass transfer devices, and its unique application in fluid dynamics has become the focus of research.

Removable ball fillers are usually made of materials with specific physical and chemical properties, such as plastics, ceramics or metals. These pellets can move freely in the mass transfer device and their main characteristics include.

First, mobility allows the packing to continuously adjust its position to adapt to different fluid flow conditions. Compared with traditional fixed packing, movable ball packing can better interact with the fluid, increasing the contact area and contact time between the fluid and the packing.

Secondly, the shape and size of the movable ball packing can be designed and adjusted according to specific mass transfer needs. Pellets of different diameters can provide different surface areas and void ratios, thereby affecting mass transfer efficiency and fluid flow resistance.

Furthermore, the movable ball filler has good wear resistance and corrosion resistance, and can operate stably for a long time in harsh working environments. This makes them have broad application prospects in mass transfer devices in chemical industry, petroleum, environmental protection and other fields.

Fluid dynamics is a discipline that studies the laws of fluid motion and plays a key role in mass transfer devices. The mass transfer process usually involves the exchange of materials between the fluid and the solid surface, and the flow state of the fluid directly affects the mass transfer efficiency.

Good fluid dynamics design can ensure that the fluid is evenly distributed in the mass transfer device and avoid local poor flow or short circuits. At the same time, reasonable fluid flow can reduce boundary layer resistance and increase mass transfer coefficient, thereby enhancing the mass transfer effect.

In addition, fluid dynamics can also affect the energy consumption of mass transfer devices. By optimizing fluid flow and reducing fluid flow resistance, the energy required to pump fluid can be reduced, achieving the goal of energy saving and consumption reduction.

The movable ball packing is constantly moving under the action of fluid. This movement makes the flow of fluid in the packing layer more complex and disordered. The turbulent flow of fluid increases the contact opportunities between the fluid and the packing surface, breaks the laminar flow state of fluid flow in traditional fixed packing, and promotes the diffusion and transfer of materials.

For example, in the gas absorption process, the movable ball packing (figure 1) can fully mix the gas and the absorption liquid, increase the solubility of the gas in the absorption liquid, and thus enhance the absorption effect. In the distillation process, the movable ball packing can promote the contact and mass transfer between the gas and liquid phases, and improve the separation efficiency.

a b

Figure 1 – Mass transfer device packing balls:
a – porous ceramic filled balls; b – chemical packing balls

The movement of the movable ball packing can continuously update the contact interface between the fluid and the packing surface, reducing the boundary layer resistance during the mass transfer process. The boundary layer is a thin area between the fluid and the solid surface, where the fluid flow rate is low and the mass transfer resistance is large. The movement of the movable ball packing can destroy the stability of the boundary layer, making the boundary layer thinner, thereby reducing the mass transfer resistance and improving the mass transfer efficiency.

In addition, the shape and size of the movable ball packing will also affect the mass transfer efficiency. Smaller ball packing has a larger surface area and porosity, which can provide more mass transfer interfaces, thereby improving mass transfer efficiency. However, small ball packing will also increase fluid flow resistance, so there is a trade-off between mass transfer efficiency and fluid flow resistance.

The fluid dynamics of the movable ball packing makes the flow resistance of the fluid in the packing layer relatively small. This is because the movable ball packing can automatically adjust its position under the action of the fluid, forming a smoother flow channel and reducing the turbulence and eddy current of the fluid.

Reducing fluid flow resistance can reduce the energy required to pump the fluid, thereby achieving the goal of energy saving and consumption reduction. In large-scale industrial production, energy saving and consumption reduction are of great significance for reducing production costs and improving corporate competitiveness.

In some mass transfer processes, the fluid may contain solid particles or impurities, which are easy to accumulate in the packing layer and cause blockage. The movement of the movable ball packing can prevent the accumulation of solid particles and impurities and keep the packing layer unobstructed.

When solid particles or impurities enter the packing layer, the movement of the movable ball packing can push them to the edge of the packing layer or out of the packing layer, thus avoiding blockage. In addition, the surface of the movable ball packing is usually smooth and not easy to absorb solid particles and impurities, which also helps to prevent blockage.

In chemical production, mass transfer devices are widely used in distillation, absorption, extraction and other processes. The application of movable ball packing in these processes can improve mass transfer efficiency, reduce energy consumption and improve product quality.

For example, in a distillation tower, movable ball packing can replace traditional plate tower packing or packed tower packing to improve distillation efficiency. The fluid dynamics of movable ball packing enable better contact and mass transfer between the gas and liquid phases, thereby achieving more efficient separation.

In the absorption tower, the movable ball packing can enhance the mass transfer effect between the gas and the absorption liquid and improve the absorption efficiency. The movement of the movable ball packing can make the absorption liquid fully distributed in the packing layer, increasing the contact area and contact time between the gas and the absorption liquid.

In the field of environmental protection, mass transfer devices are mainly used in processes such as waste gas treatment and wastewater treatment. The application of movable ball packing in these processes can improve the removal efficiency of pollutants and reduce treatment costs.

For example, in the process of waste gas treatment, the movable ball packing can enhance the mass transfer effect between gas and absorbent, and improve the removal efficiency of harmful substances in waste gas. The movement of the movable ball packing can make the absorbent fully distributed in the packing layer, increasing the contact area and contact time between gas and absorbent.

In the process of wastewater treatment, movable ball fillers can improve the treatment efficiency of bioreactors and reduce wastewater treatment costs. The movement of movable ball fillers can allow microorganisms to fully grow and reproduce in the filler layer, increase the contact opportunities between microorganisms and wastewater, and improve biodegradation efficiency.

The fluid dynamics application of movable ball packing has brought new opportunities for improving the performance of mass transfer devices. By strengthening the mass transfer process, improving mass transfer efficiency, reducing energy consumption and preventing blockage, movable ball packing has broad application prospects in the fields of chemical industry, petroleum, environmental protection, etc.

With the continuous advancement of science and technology and the in-depth study of mass transfer processes, the design and application of movable ball packing will continue to be optimized and innovated. In the future, movable ball packing is expected to play an important role in more fields and contribute to the sustainable development of industrial production.

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ОСОБЕННОСТИ ЗАПОЛНЕНИЯ ЕМКОСТИ ФИРМЫ CARBONSAN ЖИДКИМИ ПРОДУКТАМИ РАЗДЕЛЕНИЯ ВОЗДУХА

Открытое акционерное общество «Крион» является специализированным предприятием по выпуску продуктов разделения воздуха: кислорода, азота, аргона как в жидком, так и в газообразном состоянии, а также пищевых и технических газовых смесей. Его первые мощности были введены в действие в 1956. С тех пор реконструкция старых и ввод новых мощностей, совершенствование технологического процесса, применение новых конструктивных решений, направленных на модернизацию производства и энергосбережение, позволяли постоянно наращивать объёмы и расширять ассортимент выпускаемой продукции.