EQUILIBRIUM AND MASS TRANSFER ZONES: HOW TO OPTIMIZE MOLECULAR SIEVES BED SIZE

The optimization of Molecular Sieves beds size is a key factor for the overall cost of a project, as it allows Capex and Opex savings. For a given performance, shorter beds means smaller vessels and lower utilities requirements.

A Molecular Sieves bed may be divided in 2 parts:

- **The Equilibrium Zone (EZ)** is the part of the bed where the adsorbent is saturated with the compounds to be removed. It depends mainly on their inlet concentration and on the adsorbent capacity.

- **The Mass Transfer Zone (MTZ)** is the concentration gradient area, which depends, among others, on the feed flowrate and on the adsorbent particle size.

With the adsorption progressing, the EZ grows and the MTZ is pushed through the bed. Breakthrough occurs when the MTZ reaches the bed end.

Conservative designs and/or old units often only involve large particles (typically 1/8 inch beads or extrudates). However, it is possible to decrease significantly the quantity of product by the use of smaller particles in the MTZ area (typically, 1/16 inch). In the MTZ, contrary to EZ, the species have not reached the adsorption equilibrium: due to the diffusion kinetics, they are not adsorbed in the whole volume of the product, but mostly on the particles surface. Therefore, as smaller particles offer a larger specific area, the overall capacity of a given volume is higher.

A typical case, with saturated Natural Gas to be dried from 700 to 0.1 ppmV H₂O is shown on the right hand side: the typical gain is 15 to 20% of product. However, when the MTZ has the main contribution (e.g.: unsaturated flows), it can be even much more. The same example, from 150 to 0.1 ppmV H₂O leads to a 40% decrease of the quantity of adsorbent. In each case the total bed pressure drop remains the same.

Each case is specific. Don't hesitate to ask CECA specialists. They have a leading experience in designing optimized mixed beds of beads or pellets.

In the next issue, we will explain how to choose the right Molecular Sieve grade for Cracked Gas Drying.