molecular sieve

pressure swing adsorption technology

VOGELBUSCH

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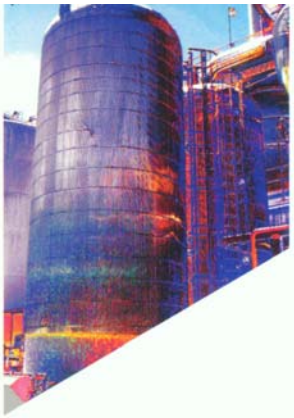

Vogelbusch Molecular Sieve

World Class Technology – Worldwide Success

Vogelbusch adsorption personnel had installed the first commercial pressure swing ethanol dryer as early as 1981. By developing existing technology and specialized process know-how, Vogelbusch pioneered the application of this process for the dehydration of ethanol. Molecular sieve dehydration technology has since replaced entrainer distillation for the production of dehydrated alcohol.

Vogelbusch can look back on decades of experience in molecular sieve design, construction, commissioning and operation, serving the most demanding customers in the petrochemical and chemical industries worldwide. Vogelbusch adsorption system applications range from dehydration and separation of liquids, gases and vapors to units for pollution control and solvent recovery, from small plants to the largest in the world.

From stand-alone units to integration into an existing factory, we can offer a reliable system uniting high performance with low maintenance requirements.

We can provide all the services connected with project realization, from process design, engineering and procurement to installation supervision and startup assistance, or turnkey delivery.

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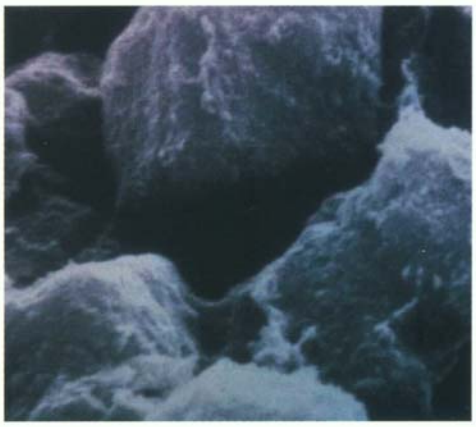
Molecular sieves

Molecular sieves are synthetic zeolites, a microporous material characterized by its three-dimensional network structure. Because of the crystalline nature of zeolites, the pores of this complex framework are of uniform size, with grades generally ranging from 3 to 10 Ångstrom (Å) units. The most important property of zeolite is its adsorption characteristics. Depending on the size of the openings, they can adsorb molecules readily, slowly, or not at all, the so-called "molecular sieve" effect - selectively adsorbing molecules of certain sizes while rejecting larger ones.

For example, in ethanol dehydration with 3A zeolites (pores of a diameter of 3 Å units), water molecules with a diameter of 2.5 Å may be retained by adsorption within the pores, but the larger ethanol molecules (4 Å) cannot enter, and therefore go through the bed.

By tailoring the chemistry and structure of the materials used to create them, synthetic zeolites can be modified to provide a wide range of desired adsorption characteristics or selectivities, and can be used as a separation tool for numerous commercial applications.



The crystalline structure, scale 1:10,000
Picture courtesy U.O.P.

Molecular sieve adsorption for ethanol dehydration

In the alcohol industry the Vogelbusch molecular sieve system removes water to produce dehydrated alcohol above the azeotropic concentration. For example, with 95 % v/v alcohol nearly all of the remaining 5 per cent of water is removed without the need for an entrainer. The product can be pharmaceutical alcohol with up to or over 99.9 % v/v, also industrial grade alcohol or bioethanol (fuel additive) with 99.5 % v/v and more.

The advantages of molecular sieve systems over other ethanol dehydration processes are:

- Most effective separation resulting in maximum alcohol concentration;
- Ease of operation;
- Reduced energy, operating and capital costs;
- Elimination of handling problems and emission control provisions associated with conventional entrainer dehydration.

Reference projects in the alcohol industry

Harbin Winery, Harbin, PRC	10,000 l/d
Central Minnesota Ethanol Co., Little Falls, USA	200,000 l/d
CAISA, Mexico	75,000 l/d
Commercial Alcohol, Chatham, Canada	430,000 l/d
Distilleries Ryssen, France	70,000 l/d
Pekin Energy, Peoria, USA	300,000 l/d
Nebraska Energy, Aurora, USA	330,000 l/d
Cargill Inc., Blair, USA	760,000 l/d
Minnesota Corn Processors, Columbus, USA	925,000 l/d
Cargill Inc., Eddyville, USA	325,000 l/d
Chief Ethanol Fuels, Hastings, USA	325,000 l/d

Process description

The Vogelbusch process for the dehydration of ethanol is an adsorption process using molecular sieve beds of pelletized synthetic 3A zeolite.

The process is based on the principle that zeolite's affinity for water changes at different pressures. The water loading of the zeolite depends on the partial pressure of the water in the feed. The partial pressure can be influenced by altering the total pressure.

The molecular sieve beds are fed with vaporous fluids. There the water of the vaporized alcoholic feed is adsorbed in the pores of the zeolite. Once the molecular sieve bed is saturated with water it has to be reactivated.

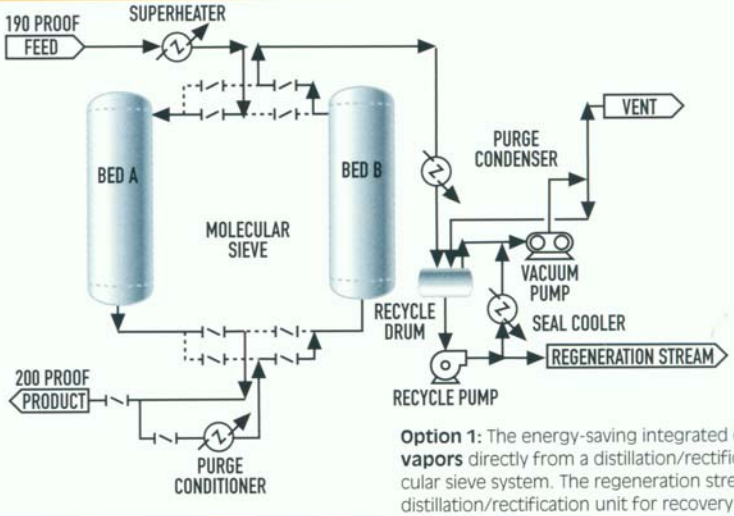
Continuous production is realized by a pressure swing reactivation (PSR) system with two molecular sieve beds. One bed is in dehydration service while the other bed is regenerated under vacuum. During regeneration, the pressure is lowered and the desorbed water is swept out of the bed with product vapors from the bed then in dehydration service. The alcohol in the regeneration stream is recovered.

Skid mounted installation

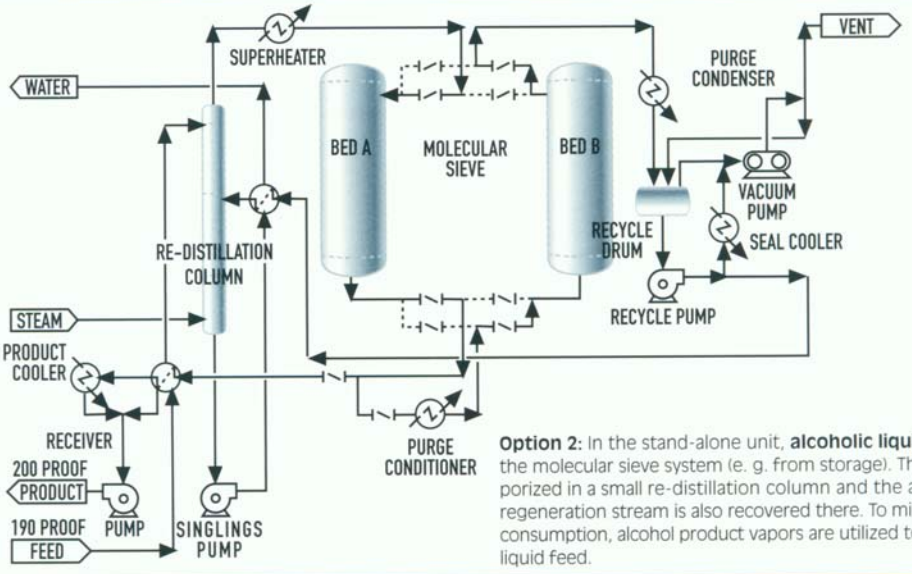
For capacities below 200,000 l/d the units can be supplied in skid mounted modules for simple installation and reduction of field erection costs. The skids are pre-assembled, piped, wired and fully tested before shipment.

Customized design options

Depending on by the client's specific requirements, there are two methods of providing the vaporized feed for the molecular sieve and recovering the alcohol in the regeneration stream:



Option 1: The energy-saving integrated design feeds **alcoholic vapors** directly from a distillation/rectification unit to the molecular sieve system. The regeneration stream is returned to the distillation/rectification unit for recovery of alcohol.



Option 2: In the stand-alone unit, **alcoholic liquid** is fed to the molecular sieve system (e. g. from storage). The feed is vaporized in a small re-distillation column and the alcohol in the regeneration stream is also recovered there. To minimize energy consumption, alcohol product vapors are utilized to preheat the liquid feed.

Model case: Chief Ethanol Inc. alcohol distillery at Hastings, Nebraska

The fuel alcohol (bioethanol) distillery of Chief Ethanol had been started up in 1983 with a continuous fermentation according to the Vogelbusch Multicont® process, with multi-pressure distillation and classic dehydration (entrainer cyclohexane). The raw material is composed of grain and maize or sorghum; draff is sold as DDGS.

This distillery was reconstructed by Vogelbusch in 1993 with the following objects:

- Capacity increase from 120,000 l/d up to 325,000 l/d;
- Replacement of entrainer dehydration by a molecular sieve unit.

A very significant improvement in plant economics was achieved by the integration of distillation, rectification, molecular sieve and evaporation processes.

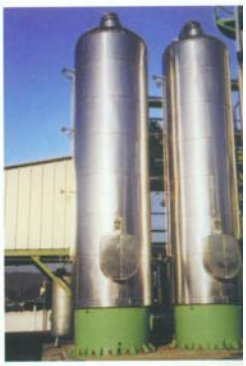
The consumption of thermal energy can be reduced by 25% by coupling the rectification column with the two-stage evaporation process. In order to achieve this effect, the rectification column works under slight overpressure and the head vapors are condensed in the first stage of evaporation. Both stages work under vacuum. A control system specially designed by Vogelbusch prevents possible fluctuations in pressure caused by the molecular sieve process.

Beer from the fermentation process is pumped to the distillation column. The 60 m column design is unique since the rectifying column is stacked on top of the stripping column, thus reducing capital cost and simplifying process control.

Alcohol is drawn via the overhead line at the top of the column at 190° proof and is condensed in the thin stillage evaporator and used as reflux. Product ethanol vapors are dehydrated to 200° proof by means of molecular sieve beds for the removal of most of the remaining 5 per cent water. The dehydrated ethanol is then condensed, cooled and pumped to intermediate storage tanks (day tanks). Once checked for product quality and specifications, ethanol is denatured with gasoline, and sent to the finished product storage tanks.

The beer bottom in the distillation column consists of water containing protein, yeast cells, fiber, and fat which are later dewatered and dried in a special installation (DDGS).

A-1050 Wien, Blechturmgasse 11, Austria - Letters: P.O.B. 189, A-1051
Tel.: +43 1 546 61-0 - Fax: +43 1 545 29 79
office@vienna.vogelbusch.com - www.vogelbusch.com



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Reference projects in other industries

Air Products & Chemicals, Mexico	feed gas adsorber
Air Products & Chemicals, Mexico	argon de-oxo
Newport News Ship Building, Norfolk, USA	high-pressure air dryer
Air Products & Chemicals, UK / Decatur, USA	feed gas adsorber
CIBA Geigy, St. Gabriel, USA	carbon adsorption system
CIBA Geigy, St. Gabriel, USA	vent system design
Shell Oil Company (Bernhard & Burk), Norco, USA	air dryer
Fluor Daniel, Surrey, UK	N_2 purification
Air Products & & Chemicals, La Salle, USA	feed gas adsorber