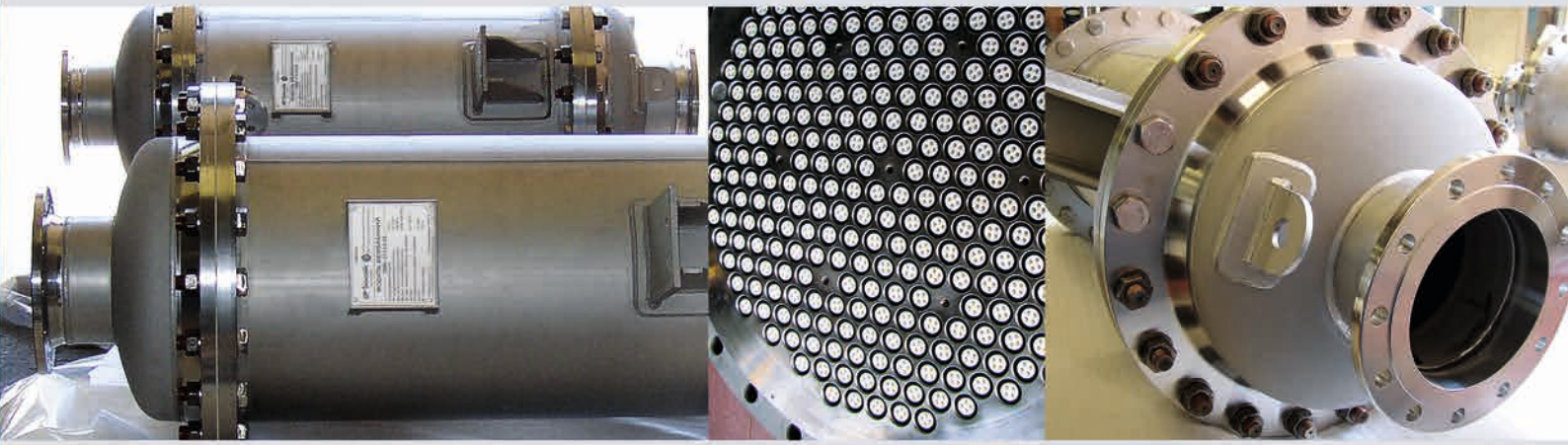
GREBENKY®
MACHINE-BUILDING PLANT

MEMBRANE TECHNOLOGIES OF ETHANOL DEHYDRATION



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PSA
Water Adsorption Using Molecular Sieves

Technology Description

This technology is based on using aluminosilicate fillers of packed columns. The vapor phase (consisting of water and ethanol) enters the column packed with aluminosilicates; water vapor (molecules of which penetrate packing material pores) is retained in the column, it gradually occupies the whole volume of the column and then it is sucked by a vacuum pump (during the regeneration process). Ethanol vapors (molecules of which are bigger than packing material pores) leave the column and enter a dehydrated alcohol condenser. The driving force for water vapor passing through the column is the pressure generated by evaporator heating vapor.

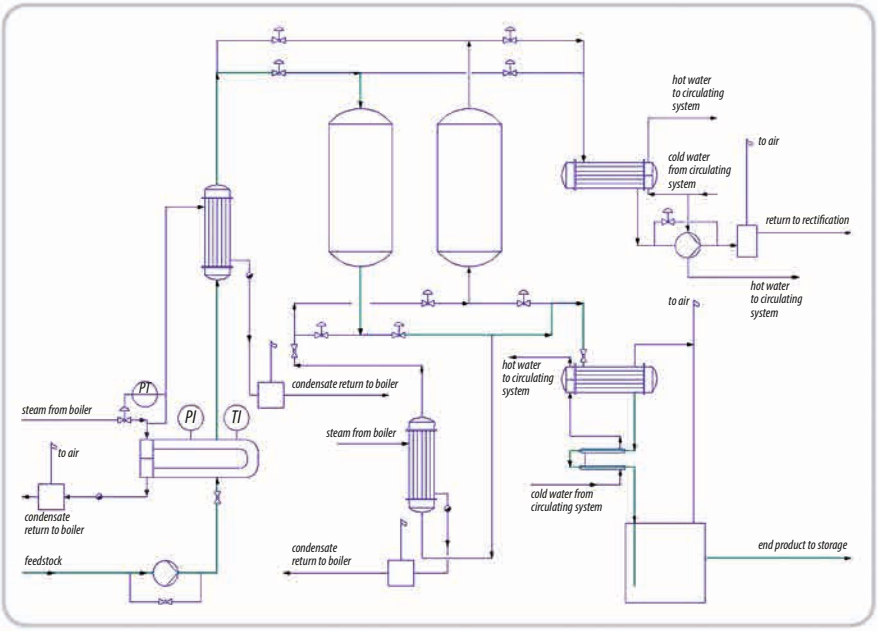
Advantages:

- well-known and well-proven technology;
- minimization of the impact of human factor on the process flow;
- the cost of the column packing material is lower than the cost of zeolite and polymer membranes.

Working parameters

Output of finished product	100.0	m^3/day
Concentration of alcohol in finished product	99.8	%, mass
Feed capacity	120.2	m^3/day
Concentration of alcohol in feedstock	94.0	%, mass
Quantity of backset (recycled material)	20.2	m^3/day
Concentration of alcohol in backset (recycled material)	75.5	%, mass
Consumables:		
heating vapor (P = 5 bars (g); t = 158.8°C)	60.0	t/day
electric power (total)	50.0	kW
cooling agent (t_{inlet} = 30.0°C; t_{outlet} = 45.0°C)	8000.0	m^3/day

Process flow diagram



SUMMARY:

The lack of alternative methods of dehydration (until recently), simplicity, reliability and cost-efficiency of the PSA method have made it the most popular way of ethanol dewatering.
At the same time, this method has its obvious disadvantages such as:

- discontinuous operation;
- regeneration;
- high energy and operating costs.

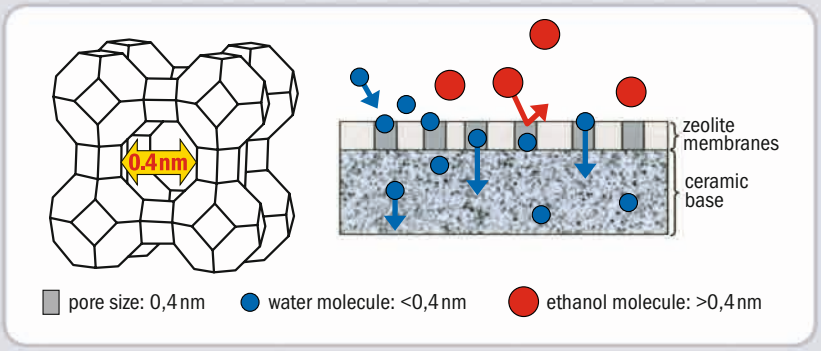
The abovementioned reasons have contributed to the development and establishment of other more advanced dehydration methods.

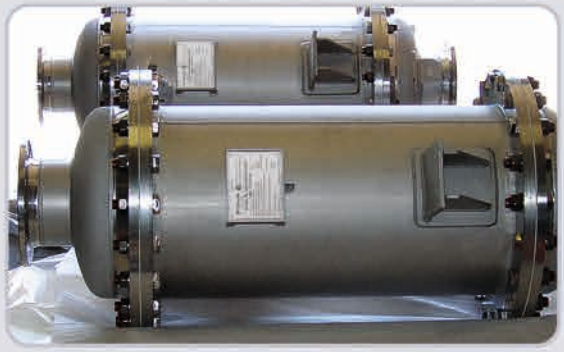
Membrane Technologies

Diffusion Membrane Separation of Liquid and Gas Mixtures

Principle of Membrane Separation:

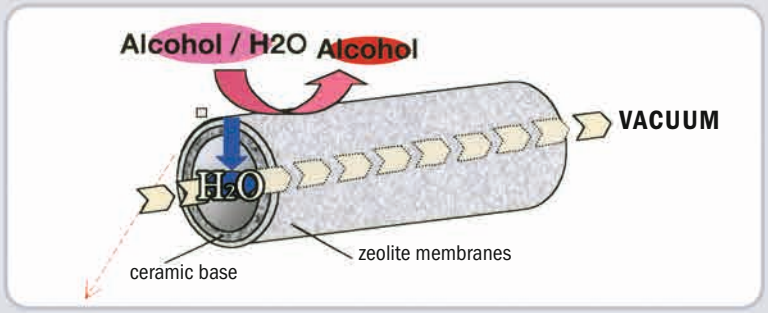
Membrane separation processes are based on selective permeability of one of the components of gas or liquid mixture. The phase passing through the membrane is called permeate (sometimes filtrate), the phase retained by the membrane is called retentate.



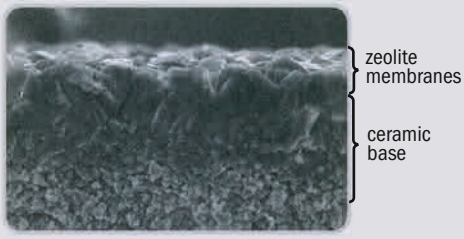


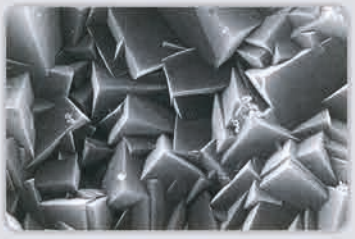
Technology Description

Zeolite membranes (type NaA) with a ceramic base have showed the high permeability to water vapor. These membranes are highly selective in evaporation through a porous membrane (pervaporation) and water vapor permeation for water-ethanol mixtures. Characteristics of the NaA membrane are proven to be better for vapor permeation than pervaporation. Mechanisms of vapor permeation and pervaporation are based on the capillary condensation of water in pores and blocking access to other molecules. Zeolite membranes are used in a form of a thin layer on the ceramic base, which allows handling large flows. On industrial scale, it is recommended to coat inside surface of ceramic elements (pipes) with a zeolite layer in order to avoid mechanical damage and to organize efficient flows. NaA zeolites in the form of membranes can be applied to monotube and multi-tube pipes. NaA zeolite membranes can be used for dewatering organic solutions, e.g. for ethanol dehydration to get the water content in ethanol below <0.2% (mass) in order to meet the essential requirement for using ethanol as a fuel. Zeolite membranes allows conducting the dewatering process with higher parameters: P = 6.5 bar (a) and t = 135°C. The dehydration equipment based on zeolite membranes due to its high level of selectivity, reliability and durability is undoubtedly superior to the existing alternatives – packed columns and polymeric membranes.

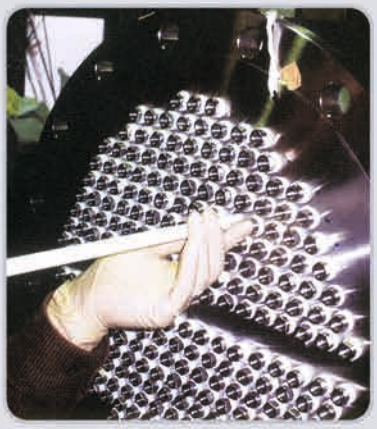


cross section view





surface area



PROPERTIES:

- chemical-resistant;
- thermal-resistant;
- mechanically durable;
- hydrophilic;
- permeability;
- selectivity;
- stability.

Vapor Permeation

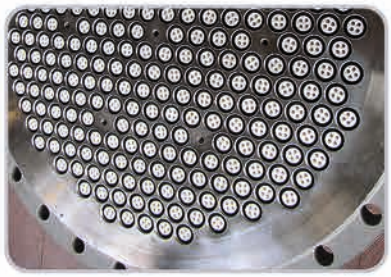
Membrane-Based Technology for Vapor Phase Dehydration

Technology Description

This technology is based on water vapor permeation through membranes for water-ethanol mixtures. The vapor phase (consisting of water and ethanol) enters the shell side of a dehydration unit; water vapor (molecules of which are smaller than selective membrane pores) passes through a ceramic pipe with zeolite coating and is sucked by a vacuum pump. Ethanol vapors (molecules of which are bigger than selective membrane pores) leave the unit and enter a dehydrated alcohol condenser. The driving force for water vapor permeation through the zeolite membrane is a pressure difference between the tube side (generated by the vacuum pump) and the shell side (generated by heating vapor of evaporator and dehydrated alcohol condenser).

Advantages:

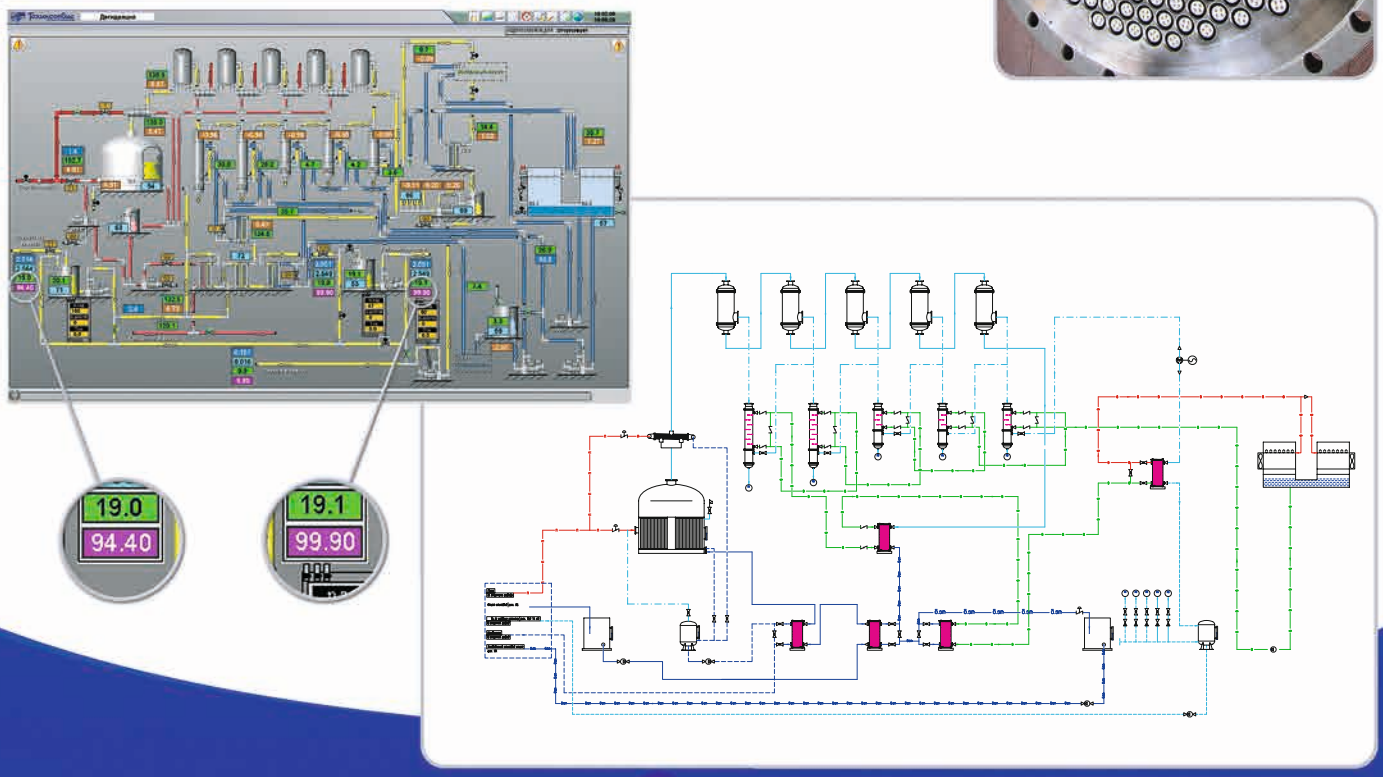
- minimum idle time (due to the low operating costs and absence of regeneration);
- high-grade dehydration (due to the high level of membrane selectivity);
- low energy and operating costs;
- minimization of the impact of human factor on the process flow;
- quick start-up and shutdown.



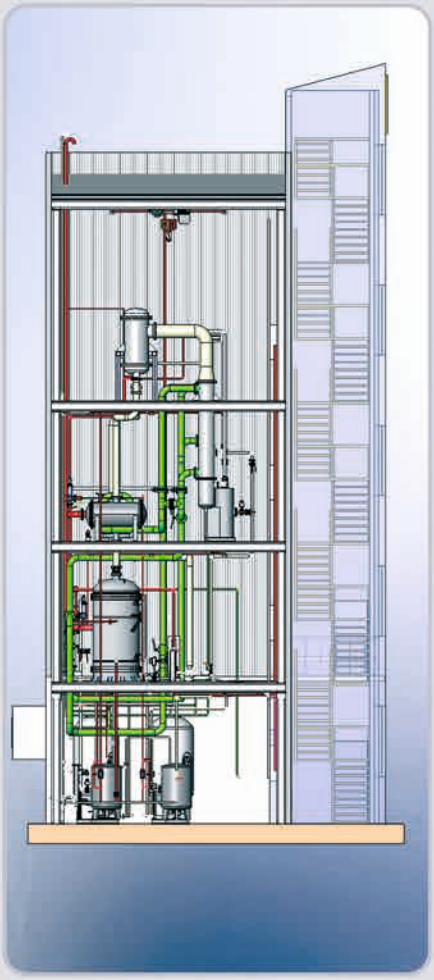
Working parameters

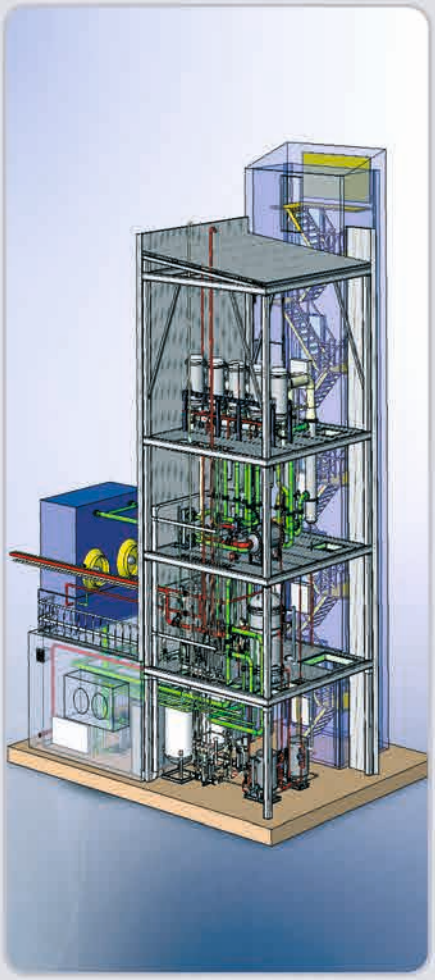
Output of finished product	100.0	m^3/day
Concentration of alcohol in finished product	99.8	%, mass
Feed capacity	104.0	m^3/day
Concentration of alcohol in feedstock	94.0	%, mass
Quantity of backset (recycled material)	4.0	m^3/day
Concentration of alcohol in backset (recycled material)	2.0	%, mass
Consumables:		
heating vapor (P = 5 bars (g); t = 158.8°C)	45.0	t/day
electric power (total)	50.0	kW
cooling agent (t_{inlet} = 30.0°C; t_{outlet} = 45.0°C)	2400.0	m^3/day
cooling agent (t_{inlet} = 5.0°C; t_{outlet} = 10.0°C)	240.0	m^3/day

Process flow diagram



Ethanol Dehydration Station





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