Air and Gas Treatment Units

Adsorption Dryers

By

Technical Deparment of Secgroup
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Index

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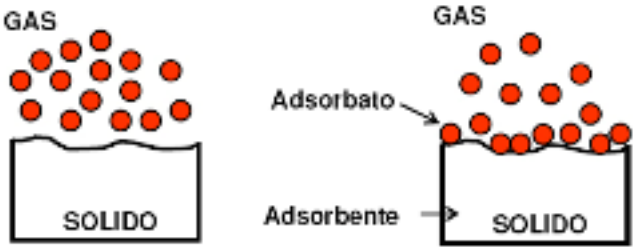
1. Phenomenon of adsorption.

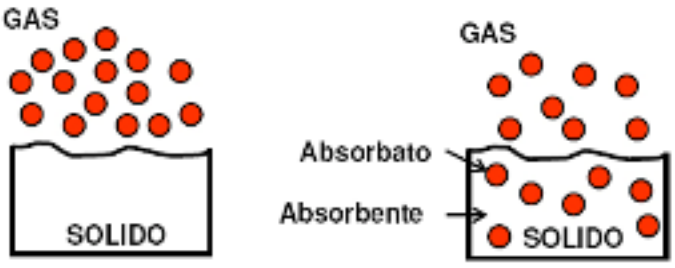
When a gas is in contact with a solid surface, part of it binds to the solid, entering it or remaining anchored to its surface. This phenomenon is called adsorption, being an exothermic process, whose heat will depend on the links formed between the gas and the solid surface.

There are two types of adsorption depending on how the gas and the solid surface react::

Physosorption: By means of weak attraction forces the gas is bound to the solid. The energy released is of the same order as the condensation enthalpy of the gas. During the process of Physisorption, the chemical identity of the gas remains intact. It is a fast and reversible process that is in equilibrium with the solid in gaseous form, determined by its vapor pressure.



Chemisorption: By means of a chemical reaction the gas and the solid are bonded. This interaction has a much stronger character and has requirements of chemical compatibility, unlike physysorption. During the process of chemisorption there is a change in the chemical identity of both the gas and the solid because a new chemical compound is formed in the bonding zone. It is a process with a generally slow kinetics and in many cases not reversible.



Adsorbent materials do not have the same affinity to all fluids. On the contrary, each adsorbent has a unique and outstanding affinity to certain fluids. This selectivity allows them to be used specifically in many fluid drying and purification processes.

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1. Adsorption dryers in Industry

The need in industry for continuous gas flows with a really low residual water vapour concentration for applications in the most diverse production processes makes the practical application of the phenomenon of physical adsorption particularly relevant.

Considering that adsorption is a surface phenomenon, good adsorbents are those with large surfaces per unit mass and high attractive forces. The most suitable adsorbent materials for the treatment of gas drying are activated alumina, silica gel and molecular sieves. The choice of one or another material is based on the characteristics and needs of the production process.

Generally, industrial adsorption dryers are of the fixed bed type. In such dryers, the drying process takes place inside a vertical vessel called a drying tower, which has a certain amount of adsorbent material. The air flows through the bed so that, the water vapour contained in the gas comes into contact with the adsorbent material and is adsorbed by it.

The gas, at the exit of the drying tower, still contains a small amount of water vapour that has not been adsorbed. This residual amount can be measured by means of a dew point meter, allowing the residual water vapour contained in the gas to be determined in degrees of temperature.

The water vapour contained in the gas flows through the drying tower, progressively saturates the adsorbent material. After a period of time it is necessary to pause the drying process in the tower, otherwise, as the gas continues to be treated, the residual water vapour contained in the gas at the outlet may start to be greater than that requested by the process.

For continuous operation, without interruptions in the supply of dried gas, there are two combined drying towers , so that when the drying process takes place in one of them, the regeneration process takes place in the other.

The regeneration process consists of releasing water vapour retained by the adsorbent material. This can only be achieved by creating a very low hygrometric level inside the drying tower. The difference in vapour tensions between the adsorbent material and the surrounding environment overcomes the adsorption forces and the water vapour molecules are released. If these conditions are kept long enough, the adsorbent material is regenerated.

The water vapour is removed from the interior of the tower by circulating a flow of sweeping gas, which incorporates the water vapour that is released from the adsorbent material and carries it with it outside the drying tower.

One of the main differences between the existing types of adsorption dryers is whether or not the swept gas flow is heated during the regeneration process. In the case of heatless regeneration adsorption dryers the swept gas has to be extremely dry, usually a fraction of the treated gas is taken up, and together with short drying/regeneration cycles, the water

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vapour is desorbed. In the case of heat regeneration adsorption dryers, which have longer drying cycles, heat input is designed to provide the desorption energy required by the process as well as to lower the hygrometric level of the sweep gas.

2. Heatless regeneration adsorption dryer

Adsorption dryers with regeneration without heat input are characterised by the fact that during the regeneration process at atmospheric pressure, only a fraction of the treated gas is used as a sweep gas, which is released through an orifice plate. The extremely low water vapour tension achieved in the sweep gas produces the desorption of the water retained in the saturated adsorbent material, restoring the ideal conditions for the next drying cycle. Short drying/regeneration cycles are required for optimum regeneration of the adsorbent material. No other energy source is used for regeneration. If the same treated gas cannot be used as a sweep gas, a gas with the same hygrometric characteristics must be used.

- Heatless regeneration adsorption dryer -

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Advantages:

1. Low acquisition cost. (CAPEX)
2. Quick commissioning.
3. Simplicity of dryer circuit.
4. Minor interventions may be carry on by unqualified personnel.
5. Excellent quality of the treated gas.

Disadvantages:

1. Important losses of dry gas.
2. Short drying cycles.

3. **Heat regeneration adsorption dryer**

The heat input regeneration adsorption dryers are characterized by the fact that during the regeneration process at atmospheric pressure, a fraction of the treated gas is used as a sweep gas, which is then expanded through an orifice plate and heated by means of electrical resistors.

The electrical resistances can be located inside the drying tower or outside protected inside a heater common to both towers. In the case of the electrical resistances placed inside the tower, they are housed inside a heat sink so that there is no direct contact between the dehydrant and the resistances, making it possible to remove them without emptying the adsorbent load from the towers.

The water vapour released during the regeneration phase is dragged by the flow of dry and hot sweeping gas to the outside of the tower. If it is not possible to use the same treated gas as the sweep gas, a gas with the same hygrometric characteristics must be used.

Advantages:

1. Less gas losses than in heatless regeneration adsorption dryers.
2. Long drying cycles ,it means less gas losses due to tower decompression when regenerating the adsorbent material.
3. Quick commissioning.
4. Simplicity of the dryer circuit.
5. Minor intervention may be carry on by non-qualified personnel.
6. Excellent quality of the treated gas.

Disadvantages:

1. High operating cost (OPEX)
2. In non-continuous service it is necessary to wait for the regeneration to finish if it was started at the time of the equipment's stop, otherwise the adsorbent would not regenerate correctly.
3. After a very long interruption, it is necessary to wait for a cycle to obtain the required dew point.

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- Heat Regeneration Duplex Adsorption Dryer -

4. **Heat regeneration adsorption dryer wit zero losses**

In opposition to heat regenerating adsorption dryers with heat input without gas losses, the main feature of heat regenerating adsorption dryers is that during the regeneration process at atmospheric pressure, a different sweep gas is used than the treated gas itself.

The sweep gas can be either an inert gas or atmospheric air driven by a blower, with no losses of the treated gas, without taking into account losses due to tower depressurisation. In this type of adsorption dryer the source of heat is electrical resistances protected inside the heater, common to both drying towers of the equipment.

The water vapour released during the regeneration phase is carried away by the sweeping gas flow to the outside of the tower. A cooling system is required for the regenerated tower before it is put back into service.

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- Adsorption to heat regeneration duplex dryer without gas losses -

Advantages:

1. Practically no loss of gas.
2. Long drying cycles , what means minimum gas losses due to tower decompression when regenerating the adsorbent material.
3. Excellent quality of the treated gas.

Disadvantages:

1. High operating cost (OPEX)
2. Complexity in the dryer circuit.
3. In a non-continuos process, if equipment was started after have been stopped, it is necessary to wait for regeneration to be completed, otherwise the adsorbent would not regenerate correctly.
4. After a very long stop, it is necessary to wait for a cycle to obtain the desired dew point.

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5. Hybrid adsorption dryer

As the conditions of the gas to be treated are not always the most appropriate for the adsorption process.
In the case of high temperature and/or relative humidity of the gas at the entrance of the equipment, a pre-treatment of the gas must be carried out. These dryers receive their name precisely from the fact that the gas they treat is pre-conditioned by other equipment of different technology.

The pre-treatment consists of reducing the temperature of the gas and removing the condensates generated. In this way, the amount of water entering the drying tower is lower, reducing the amount of adsorbent material needed and allowing the drying cycles to be extended. The temperature reduction is achieved by means of a gas/air or gas/water heat exchanger.

If the performance of the adsorption dryer wants to be improved, the use of a refrigeration dryer as a pre-treatment of the gas to be treated will be optimal in order to obtain ideal temperature and relative humidity conditions for the adsorption process.

- Hybrid adsorption dryer -

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Advantages:

1. High temperature and humidity of the gas to be treated.
2. Long drying cycles ,that imply less gas losses due to tower decompression when adsorbent material is regenerating.
3. Quick commissioning.
4. Excellent quality of the treated gas.

Disadvantages:

1. High operating cost (OPEX)
2. Complexity of dryer circuit.

6. **Design characteristics**

Gas Flow:	from 15 to 8000 m^3/h
Gas Temperature:	from 10 to 70ºC
Gas Pressure:	from atmospheric pressure to 300 bar(g)
Construction material:	Carbon steel Stainless steel Copper and aluminium alloy free materialsMateriales de
Constructive Codes:	ASME VIII Div.1 AD 2000-Merkblatt EN-13445 SELO
Regulations:	PED TEMA ATEX
Dryer control:	Discrete logic PLC (Programmable Logic Controller) From DCS industrial plant - terminal boxes

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