FOOD INDUSTRY

The significance of humidity
in production and storage

Humidification, Dehumidification
and Evaporative Cooling

The necessity of dehumidification in the food industry

During production, processing, packaging and storage of food, compliance with hygiene and handling regulations is of decisive importance for a high product quality. At the same time, to ensure trouble-free efficient production processes, constant, closely monitered room temperatures and room humidity must often be ensured in addition to good indoor air quality. These are, however, continuously impaired by moisture ingress due to warm, humid outside air, as well as by the moisture released by personnel and products. Depending on the type of food and its processing, there is a wide range of conditions to consider from high room temperature with high humidity to low room temperature with low humidity. This is especially of concern where hygroscopic substances such as powders, flour and sugar are used and processed.

Low humidity is of utmost importance to avoid product clumping and production downtimes. This brochure specifically addresses the topic of ensuring low indoor humidity in the food industry.

For this purpose, various processes and techniques for particularly reliable, efficient and economical air dehumidification are presented.

The dehumidifiers to be used for this purpose can, depending on their functional principle and performance, separate even very large quantities of water vapor from the air in a very short time and thus ensuring all required moisture levels from medium to very low.

Thermodynamics: How dehumidification works

In thermodynamics, the values enthalpy (h), temperature (t) and humidity (x) are inseparably related. The representation of these values is displayed in a psychrometric chart. Here the enthalpy **h** represents the total heat content of the air, consisting of the air temperature and the water vapor present in the air. With the humidity one differentiates still the absolute humidity **x** (g water vapor in the air per lb air) and the relative humidity. The relative humidity (ϕ) indicates to what percentage of saturation is present in the air. When it comes to dehumidifying air for a process or to ensure that the target room air conditions are met, the following is an example.

Example 1
Ensuring a humidity of 50% at a room temperature of 68'F.

During the processing of a food product constantly releasing 14 grains of water per pound of air into the ambient air (20°C, x = 7.2 g/kg).

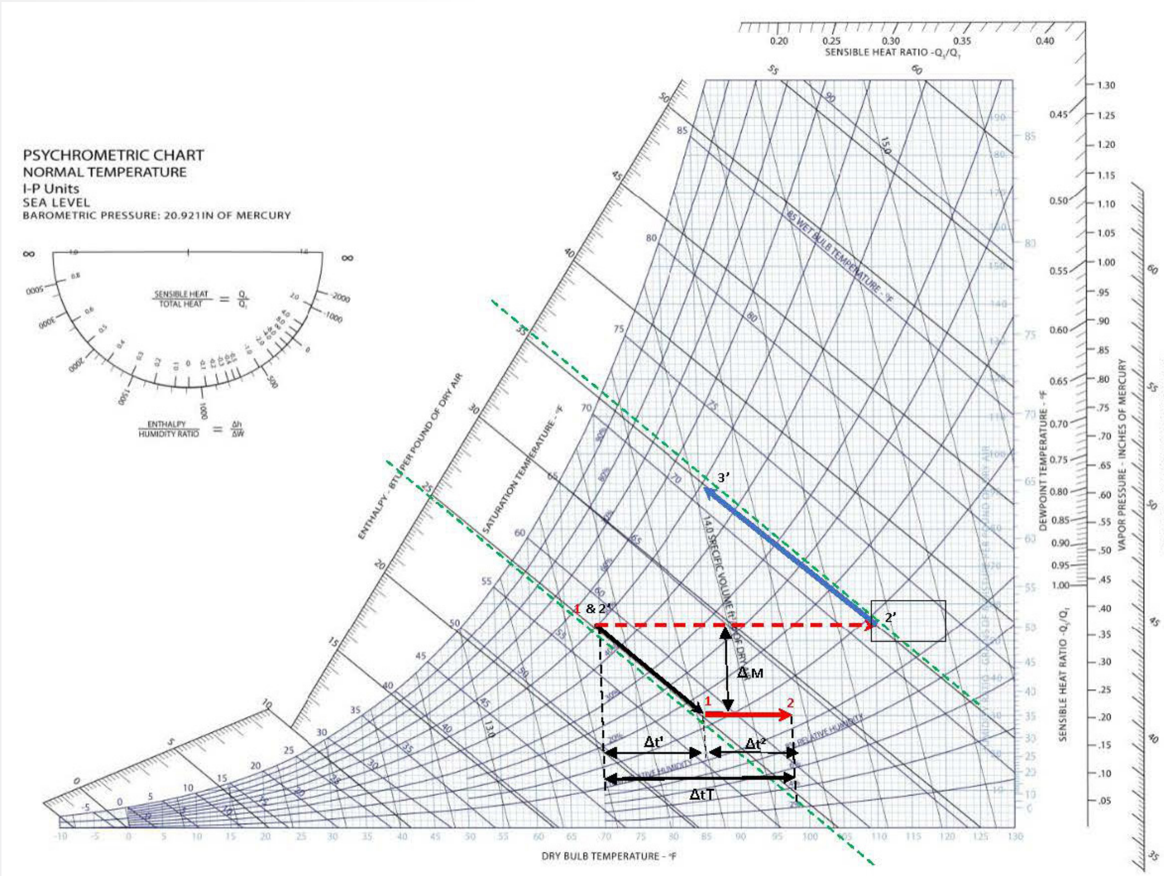
This water is absorbed by the air as water vapor.

As a result, however, the humidity of the room air rises to a value of about 85% and at the same time the room temperature drops to about 15 °C. by running an air dehumidifier installed in the room (for example a condensing air dryer), which continuously draws in room air and dehumidifies it, the required room conditions are maintained.

Example 2
Dehumidification of an air volume flow to 12 °C and a humidity of 3 g/kg (shown in the h,x diagram on the opposite page). Many production processes and the storage of food require low temperatures and very low humidity. It is assumed that an outdoor air volume flow with a temperature of 32°C and a humidity of 14 g/kg (47%) is limited to a supply air condition of 12°C and a humidity of 3 g/kg (35 %) should be dehumidified. For this purpose, an adsorption dryer is best applied. The change of state of the outside air to the supply air follows the course of the red straight line in the psychrometric chart. Step 1 is a pre-cooling and pre-dehumidification of the air to 15 °C and a humidity of 10 g/kg. In step 2, the air is dried in the adsorption dryer to a humidity of about 3 g/kg, which raises the temperature to about 40 °C. In the third step now dry air is post-cooled to the supply air temperature of 12°C.

Following these brief theoretical principles, the subsequent pages contain further examples of air drying of various foods.

More detailed information on typical areas of application, technical working methods and properties of condensation and adsorption dryers can be found on pages 14 to thru 17.



PSYCHROMETRIC CHART
NORMAL TEMPERATURE
I-P Units
SEA LEVEL
BAROMETRIC PRESSURE: 20.921IN OF MERCURY
SENSIBLE HEAT / TOTAL HEAT = Qs/Qt
ENTHALPY / HUMIDITY RATIO = Δh/ΔW
SENSIBLE HEAT RATIO -Qs/Qt
DEWPOINT TEMPERATURE - °F
VAPOR PRESSURE - INCHES OF MERCURY
ENTHALPY - BTU PER POUND OF DRY AIR
SATURATION TEMPERATURE - °F
DRY BULB TEMPERATURE - °F
85 WET BULB TEMPERATURE - °F
14.0 SPECIFIC VOLUME FT³/LB OF DRY AIR
RELATIVE HUMIDITY
1 & 2'
1
2
2'
3'
ΔM
Δt¹
Δt²
ΔtT

Improvement of production quality and consistency

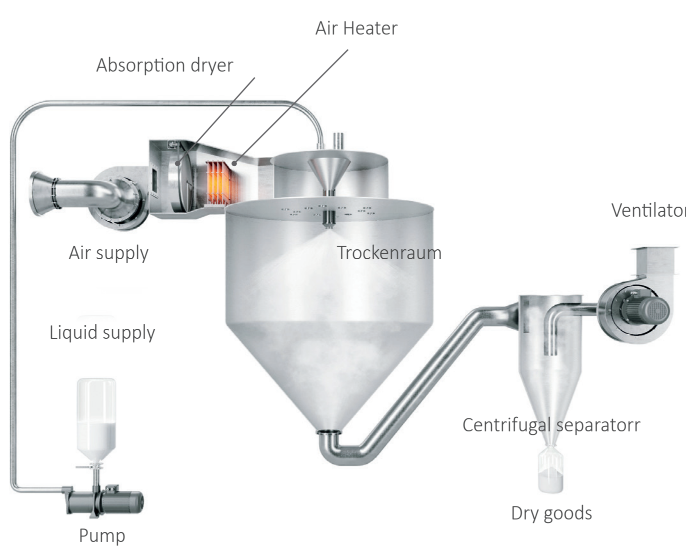
Spray-drying is commonly used in the food industry where liquid products are turned into powders. These are either then sold as finished goods or are used as basic substances for the production of other products. Spray dried products include powdered milk and instant coffee. In the manufacture of powdered milk the process of spray-drying completely removes the water from the milk. This process is divided into three steps.

The first step involves atomizing the milk concentrate, which has been pre-dried concentrated by evaporation, into very fine droplets, thus increasing its surface area by a factor of 1,000. At the same time, air is introduced into this process in step two, which has previously been filtered, heated and dried. The hotter and drier this supplied process air is, the higher the drying speed. Within a short time, the air flow completely removes water from the fine milk droplets, and removes it from the process. As the water is absorbed, the process air humidity rises and thus cools down. In the last step, the now powdered dry milk is separated from the air stream in a cyclone separator. This process produces approximately one pound of dry milk powder from about 1US gallon of milk concentrate. Milk powder is commonly used in the manufacturing of cheese, yogurt, confectionery particularly chocolate and baked goods; it is also a major constituent of instant baby food.

The process of spray drying is employed in the production of, many other food powders and is used extensively in the pharmaceutical industry.

The use of adsorption dryers is the ideal solution for the spray drying process. In the adsorption drying process, not only is the air humidity reduced, but the air is also heated. This warming is beneficial to the spray drying process, since heating air requires large amounts of energy. The warm dry air from a Condair DA unit significantly improves the efficiency and economy of the spray drying process.

The use of adsorption dryers is the ideal solution for the spray drying process. In the adsorption drying process, not only is the air humidity reduced, but the air is also heated. This warming is beneficial to the spray drying process, since heating the hot air requires large amounts of energy. This significantly improves the efficiency and economy of the spray drying process.



Hygroscopic raw and production materials

In order to avoid damage of raw materials and ensure the raw material quality to ensure the best possible production yields, it is necessary to design dehumidification systems that are precisely adapted to the needs and processes of the manufacturing companies. As a rule, system solutions start with the control of humidity levels that are in equilibrium with the raw base stock materials moisture content and Equilibrium Relative Humidity. The important thing to remember is that even slight deviations from the "ideal" moisture content can have a negative effect on the materials used and their specific characteristics, as well as on possible reactions between them during further processing. In addition to ensuring reliable quality, it is also important that the consistency and viscosity of the products in terms of their pouring and flowability remains constant. This is important for the appropriate storage, conveying and dosing systems being applied.

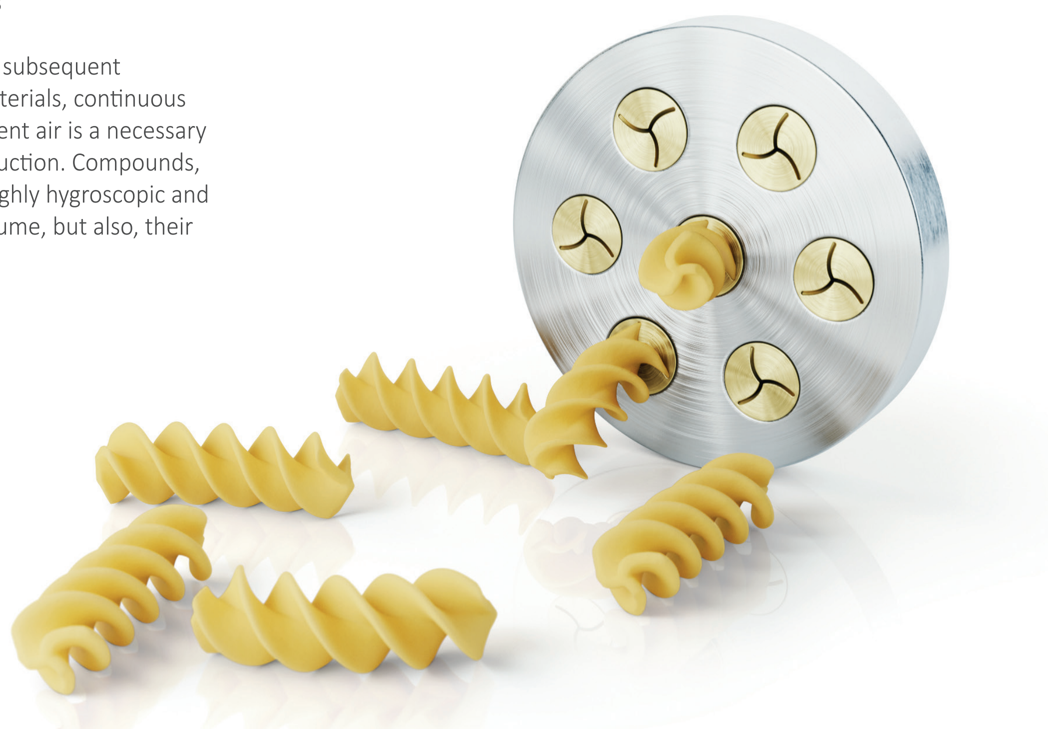
color and other specifics when they absorb water. The decisive factor, however, is that the quality of the products and their individual components can also deteriorate to the point of uselessness or inedibility.

Whereas flour for example, quickly forms lumps when it absorbs moisture. Sugar and salt absorb water to a point where it deliquescence's and it turns to liquid. As can be seen from the graph below up to around 75% humidity there is no change in moisture content. Once it reaches its deliquescent point its moisture content climbs vertically.

To prevent the consequences of these reactions or processes, the use of effective dehumidification solutions is absolutely necessary.

Water-binding raw materials

For industrial production and subsequent processing of hygroscopic materials, continuous dehumidification of the ambient air is a necessary prerequisite for optimal production. Compounds, like starch for example, are highly hygroscopic and can change not only their volume, but also, their



Dry substrate during label application

When labelling bottled beverages, excessive humidity in the vicinity of the production can damage the label of the filled bottles. The problem is: When the cool filled and labelled bottles are brought into the warehouse, there is a risk of condensation on the bottle surface. This can have a disastrous effect on the adhesive of the label through softening, causing loss of adhesion and the label slips off the bottle. This problem can be prevented by dehumidification at the storage and labeling locations.

Whether there is mold on the corners and edges or the labels are unusable due to creasing, slipping or peeling: The use of current and efficient dehumidification technologies effectively prevents these problems.

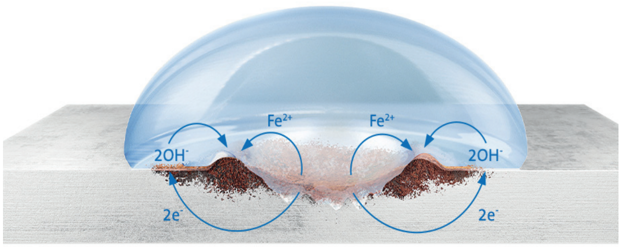
Dehumidification of the air ensures hygienic production conditions

Condensate contamination
Precise, application-optimized dehumidification plays a decisive role in maintaining the hygiene regulations and standards required in the food industry. In production processes with perishable foods, room temperatures in production, laboratory or storage rooms must be kept at a low level. If warmer air enters the room, for example through the (necessary) opening of the room entrances, the moisture that simultaneously penetrates can quickly create condensation on ceilings, walls or on the surfaces of the equipment and furnishings. In areas where permanent moisture precipitation occurs, the floor is prepared for the formation of microorganisms such as fungi and bacteria. Similarly, the condensing moist air has a similarly negative effect mainly on the metallic components of appliances or furnishings. This favors the development of corrosion and risk of contamination by condensed water making it more difficult to comply with the required hygiene regulations.

Corrosion damage
Condensed water often settles on large surfaces of pipelines and fittings which cold water flows through. The lower the temperatures are on these surfaces; the more condensation risks increase. The consequences of this can be far-reaching and consequently costly. Over time, the permanent exposure to moisture causes corrosion to build up in the affected areas.

Worse still, depending on where the piping systems are located, the condensed water can also enter production or storage tanks and cause considerable damage to equipment and product. The use of dehumidification systems based on adsorption technologies prevents condensation, corrosion and mold formation., Thus, preventing permanent damage to products and production facilities.

How corrosion develops



When the air is sufficiently dry, iron cannot rust. However, when moisture settles on the metal, oxygen (O2) and water (H2O) begin to react to form hydroxide ions (OH-). To balance the electrons needed for this reaction, the iron oxidizes. This means it gives off its electrons, which are then taken up by the oxygen. This process produces iron oxide, or rust. In places where electrons have been withdrawn, a shortage of electrons occurs and positively charged iron atoms (Fe2+) are released. These migrate into the water droplets and combine there with the negatively charged hydroxide ions (OH-). In the first step, iron(II) hydroxide is formed by different charges. Additional reactions with water, oxygen and hydroxide ions lead to ever more continuous reactions from which iron(III) oxide and iron(III) hydroxide are formed. These deposit on the metal surface and give the rust its typical appearance. In contrast to metals such as aluminum, the process is only stopped when iron is no longer present.

Moisture penetration at high cleaning intervals

For hygiene reasons alone, frequent cleaning measures, often several times a day, are a must in many food companies. In the meat processing industry, for example, the machines, work surfaces and floors used must be cleaned up to three times a day to achieve the required level of cleanliness and hygiene. Wherever cleaning is carried out using high-pressure or steam cleaners, for example, large quantities of moisture are released. If this moisture is not consistently removed after the cleaning process, it will settle on the processed meat products and find a breeding ground for microorganisms. Dehumidification prevents possible mist formation, provides a more pleasant working climate for employees, and prevents safety hazards from slipping on wet floors.

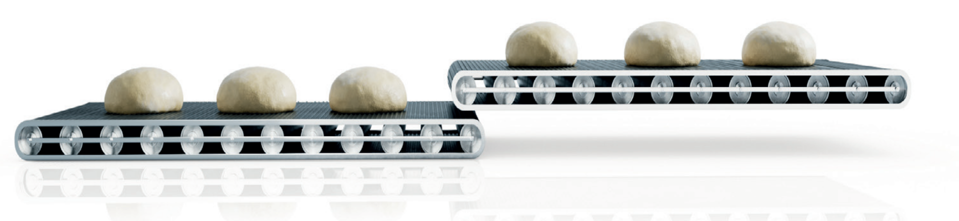
The crispness of baked good and snack foods

Everyone knows: Cookies, potato chips, pretzels and pretzel sticks that are stored in the open for a certain period of time lose their "crunch" or crispness- they draw moisture from the ambient air and absorb it. In baked goods that consist primarily of the hygroscopic ingredients; flour and sugar, the desired properties can be ensured by air humidity management. Wherever bread is baked and stored, i.e. in bakeries or, even more extensively, in the industrial production of baked goods, the use of effective dehumidification systems serve to maintain the appropriate product quality and prevention of mold formation.

Conveyance of general cargo and bulk materials

To ensure optimal food production, the interaction between the processes used and the products produced must be right. The one-sided focus on high product quality is usually not enough. Above all, production must also meet the high demands of competitiveness; achieving the greatest possible efficiency is an ongoing issue, especially in the food industry.

Minimal downtime
An essential component of process quality here is an unimpeded, consistently efficient production flow of the conveyor and transport. If their environment is not sufficiently dehumidified, product buildup or sticking to conveyor belts or clogging of conveyor paths caused by lump formation can severely disrupt the production process. Intelligent dehumidification solutions offer food manufacturers optimal control and management of their processes.

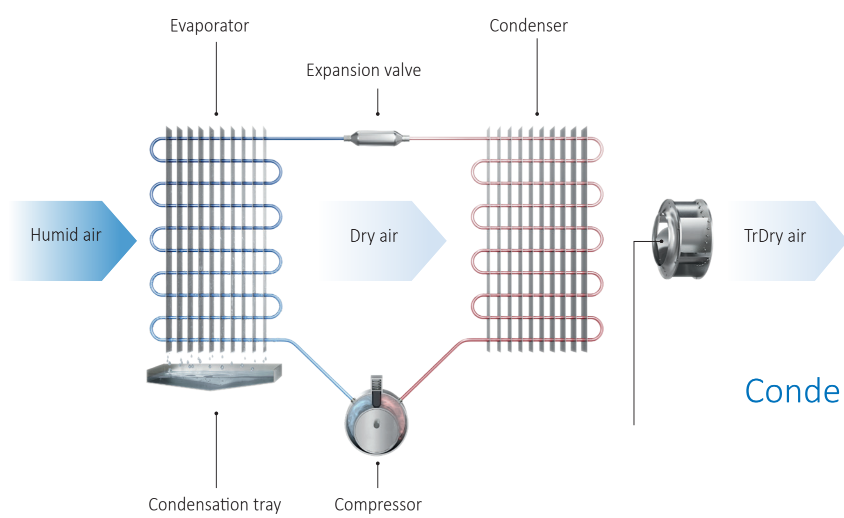


Selecting the right dehumidification technology

Demonstrated earlier in the brochure, the food industry faces a variety of challenges when dehumidifying air. Depending on the type of production, processing and storage of food, the spectrum ranges from high temperature with high humidity to low temperature with low humidity. One way to dehumidify air is to operate ventilation units with integrated water coolers. In this case, the outside air drawn into the ventilation unit is cooled down considerably in the cooler, thereby dehumidifying it and then introduced into the room. This type of dehumidification, however, is often only sufficient to trim during in muggy humid weather, the humidity values that can be achieved from an economic point of view often do not correspond to the required target conditions and must be further dehumidified. To significantly reduce the operating costs for air dehumidification, secondary air dehumidification units are typically applied. These dehumidify either a required partial air volume or are installed directly in the room. There, they constantly draw in room air, which is filtered, dehumidified and then supplied back into the space as dry supply air. Both methods of dehumidification have advantages and disadvantages and must be tested and evaluated for each individual application. For direct installation in the space, in addition to the internal moisture load in the space, the external moisture load, e.g. mechanical ventilation in summer, must also be taken into account. The dehumidification units used for this purpose are available as condensation air dehumidifiers and adsorption dryers.

Condensation dehumidifiers are ready-to-use units for standard dehumidification processes in which a relative air humidity of up to 40 % is to be maintained at a room temperature of about +5 to +35 °C. The units contain a refrigerating machine with compressor, evaporator and condenser. As shown in the figure below, the fan draws moist room air into the unit, filters it and then passes it through the evaporator. Liquid refrigerant flows in the evaporator, which extracts heat from the air and evaporates it. This cools the air so much that it falls below its dew point and water condenses out of the air. The lower the temperature in the evaporator, the more water is removed from the air as condensate and the drier the air becomes. The water is collected in a condensate tray and discharged into the drain. The now dehumidified but cool air then flows through the condenser of the refrigerating machine. There it is heated by the heat of condensation and flows back into the room as dehumidified supply air. Due to the continuity of this process the room air is constantly dehumidified to the desired setpoint value.

Adsorption dryers are used when a moisture content of less than about 45 %rh is required, often at very low temperatures. In this application, condensing dehumidification of the air would be too costly and energy-intensive. An adsorption dryer consists of a sorption rotor, air filters, two fans for conveying the process air and the regeneration air, a heater for heating the regeneration air and the associated control system (see figure below). The use of Adsorption dryers is not limited to humidity levels below 45% or applications

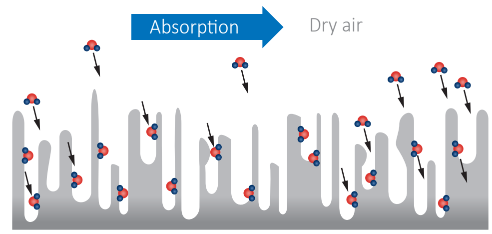


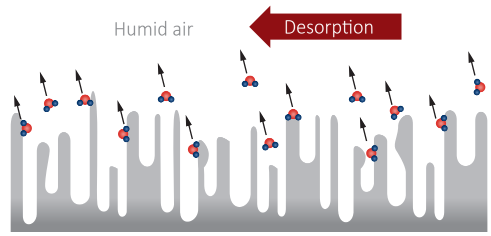
Operating Principle
Condensation Dehumidification
Compressor

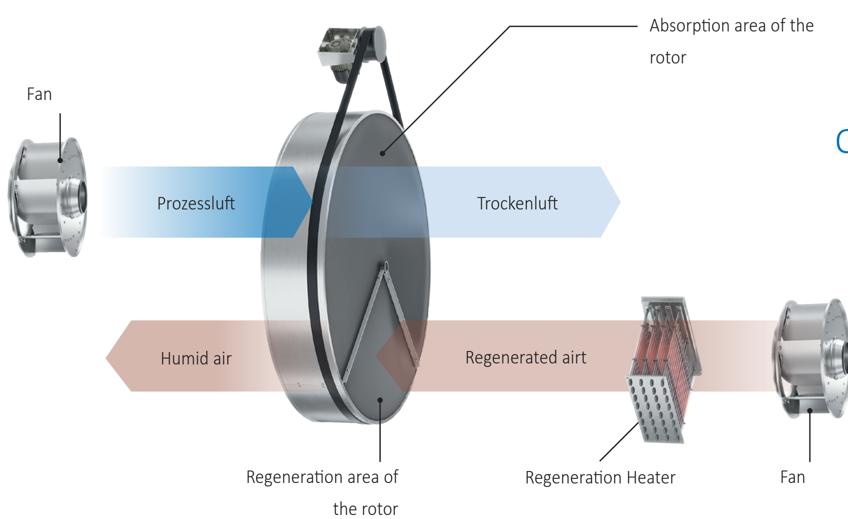
at low temperature. Any form of condensing dehumidifier will typically give control in the order of +/-10% either side of set point. Whereas desiccant adsorption driers will control to +/-2% rh.

The process air fan conveys air for drying into the device. After an air filter, the air reaches the slowly rotating sorption rotor. This consists of over 82% silica gel on a fully bonded air-permeable glass fiber honeycomb structure. Due to its extremely large inner surface of up to 240000sqft/ounce, the silica gel is very hygroscopic and can therefore absorb large amounts of water from the process air on the surface and store it in its internal structure.

Two processes take place simultaneously as the air flows through the sorption rotor:
The process air can be dehumidified effectively. However, depending on the intensity of dehumidification, the air temperature may rise significantly. Therefore, it is often necessary to cool the now dehumidified but warm air before returning it to the room. For this dehumidification process to work, the sorption rotor must be continuously regenerated: This means that the moisture stored in the silica gel must be constantly removed from it. This is done with regeneration air, which flows through the sorption rotor from the other side in countercurrent. The regeneration air is heated, and consequently the relative humidity drops so much that it is sufficient to expel the water from the silica gel and bind it as steam in the air (desorption). The now humid regeneration air leaves the adsorption dryer and, if necessary after a supplementary heat recovery, is blown out to the outside air. Hot water, steam, gas burner or electrical energy are used as media for heating the regeneration air.







Operating Principle Absorption Drying

Absorption Dryer
Condair DA series

Wherever very low humidity levels are required, for example in industrial drying processes or applications with very low temperatures, Condair adsorption dryers of DA series are used.

The silica-gel coated sorption rotor operates practically wear-free under optimal operating conditions and enables safe operation down to temperatures of-30°C and the achievement of even the lowest possible humidity. The silica gel used as drying medium is not respirable and not flammable.

Alongside standard versions with dehumidification capacities from 0.6 to 182 kg/h for process air flows from 120 to 27,000 m³/h, the DA dryers are also available in many special designs.

For example, the units can be equipped at the factory with pre and/or post-cooling coils, heat exchanger or condensation modules. As a results of the heat gain it is often necessary to install after-cooling of the dried, but thereby heated process air should be taken into account at an early stage in the plant design. In addition to the selection of different regeneration processes, it is also possible to use already existing media such as steam or hot water.

The combination of these media with the electrical regeneration heater integrated in the unit allows considerable savings in operating costs, especially for larger systems.

Depending on the current operating conditions, all processes in the adsorption dryer are controlled to the target conditions of the supply air either via the on-site MSR or optionally via the PLC installed in the unit.

Condair DA 300 - 4400
Diverse customer-specific
configurable adsorption dryer, especially for use in production areas and large rooms.

Nominal drying capacity**
3.3 - 54 kg/h.

**at 20°C - 60 % r.h.

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