Gas treatments Units

Refrigeration Dryers

By

Secgroup Technical Deparment
www.secgroup.es

Index

AIRSEC, S.A C.I.F ESA08072076
P.I El Pedregar
C/ Progrés 6-8
08160 Montmeló
Barcelona -España
Tel: +34 935 721 222
Fax: +34 935 684 556
Email: info@secgroup.es
Web: www.secgroup.es

1. Introduction

All compressed gases contain impurities which could cause damage to installations and components if they are not removed. These impurities consist of water, dust, rust and oil from compressor lubrication among others.

In the case of water in liquid or vapour state, it is responsible for early wear and tear on the components of the installation, as it carries oil that lubricates the moving parts, produces rust particles in the distribution pipes, damaging the flexible pipes and promoting the formation of ice in a low temperature working environment.

The removal of water in compressed gas installations is carried out by installing drying equipment at the outlet of compressors. Depending on the desired degree of water removal, these units can be either adsorption, refrigerator or chiller type.

- Refrigerated plate dryers for the PET Blowing Industry -

2. Refrigeration dryers

The water vapour content of any gas or gas mixture is limited by the temperature. At specific temperature, the gas may retain a quantity of water vapour at most, the lower the temperature of the gas, the smaller the quantity. It is therefore possible to reduce the water vapour content of a compressed gas by cooling it. The excess water vapour condenses and, already in the liquid phase, can be easily removed from the gas flow.

This is the physical phenomenon that occurs in final coolers, cooled by ambient air or water, which are installed at the outlet of the compressors. However, the name refrigeration dryer is used only for equipment capable of cooling the compressed gas to temperatures much lower than the ambient temperature. These units are equipped with a refrigeration system capable of reducing the temperature of the compressed gas to around +3C. It must not cool below 0C, as ice will form on the heat exchange surfaces, blocking the passage of the gas and/or reducing the heat transmission.

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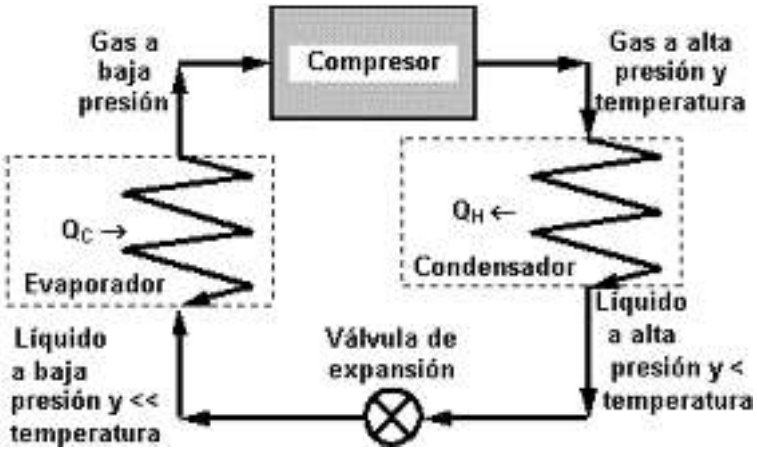
This type of dryer consists of a gas/refrigerant heat exchanger called evaporator, where the compressed gas to be treated is cooled by transferring heat to a refrigerant fluid that evaporates, and a gas/gas exchanger called economizer, since the cold compressed gas leaving the evaporator pre-cools the gas entering the dryer, reducing the necessary cooling power of the equipment. Between the heat exchangers, a condensate separator continuously and reliably removes the condensate generated by an automatic purge. As they can be easily adapted to changing operating conditions, refrigeration dryers are very cost-effective due to their low operating costs and minimal maintenance.

3. Refrigeration system

Refrigeration dryers use compression refrigeration, which consists of mechanically forcing the circulation of a refrigerant fluid in a closed circuit, by creating high and low pressure zones so that it absorbs the heat of the compressed gas to be treated that circulates inside the evaporator and dissipates it outside the evaporator, in order to reduce the temperature of the evaporator and to condense the water vapour.

Compression cooling is achieved by evaporating a refrigerant fluid in a liquid state through an expansion device inside a heat exchanger, the evaporator. In order to perform the change from liquid to gas state, the refrigerant needs to absorb latent heat of vaporisation that comes from the thermal load of the compressed gas to be treated. After this energy exchange, a mechanical compressor is responsible for increasing the pressure of the refrigerant fluid in order to condense it inside another heat exchanger known as the condenser and make it liquid again, repeating the compression refrigeration cycle.



4. Direct expansion refrigeration dryer

In drying units with small and medium thermal loads of the compressed gas to be treated, the evaporator is designed in such a way that the compressed gas to be treated circulates on one side and the boiling refrigerant on the other. This type of refrigeration dryer is called a direct expansion dryer because the compressed gas to be treated and the refrigerant fluid exchange heat directly between them through the walls of the heat exchanger.

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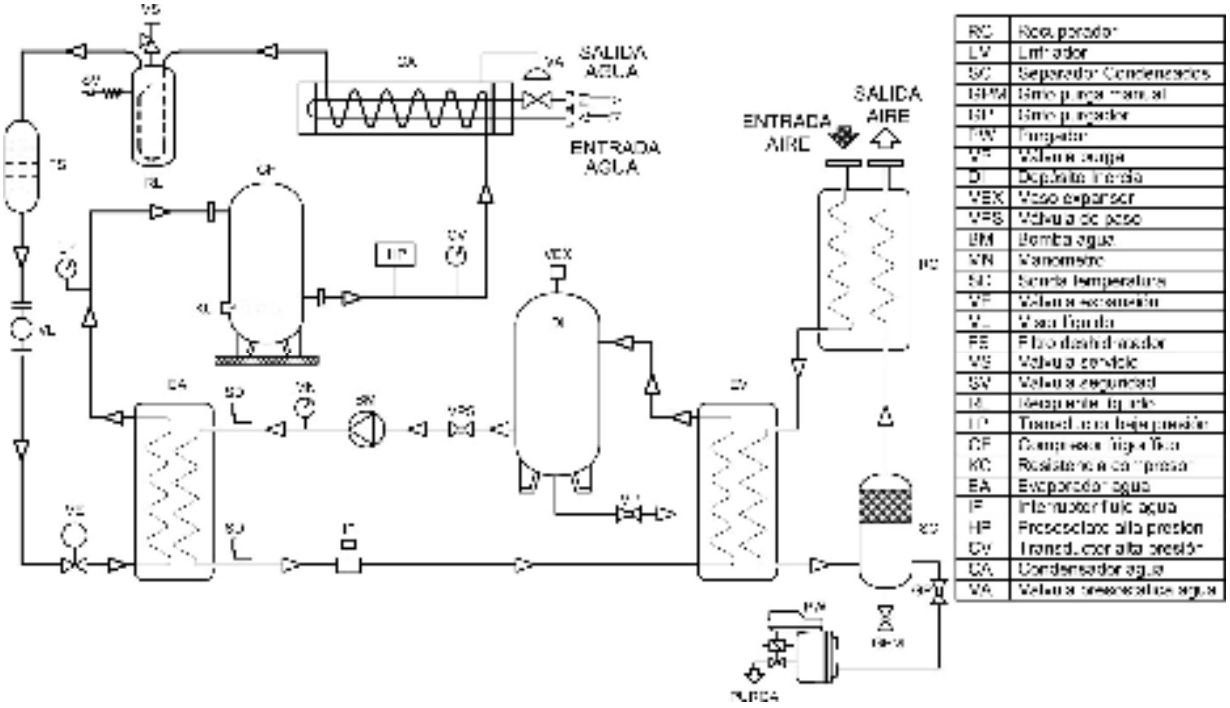
5. Indirect expansion refrigeration dryer

In equipment with a high thermal load of the compressed gas to be treated, associated with high flow rates and low working pressures, the heat transfer between the compressed gas to be treated and the refrigerant fluid does not take place directly in the evaporator, but through an intermediate cold fluid in a heat exchanger called a chiller. The aim is to increase the thermal inertia of the system and improve the stability of the outlet temperature of the treated compressed gas against fluctuations in working conditions.

The intermediate fluid is a liquid mixture with a low freezing point to prevent it from freezing inside the pipes and heat exchangers. Driven by a pump in a closed circuit without losses, it circulates inside the cooler extracting the heat from the compressed gas to be treated. On leaving the chiller, it is directed to a storage tank thermally insulated from the environment from where the pump pushes it to the fluid/chiller heat exchanger called evaporator, connected to a refrigeration system, where it cools down again.



- Operation diagram of indirect expansion refrigerant dryer -

If the thermal load of the compressed gas in the cooler decreases due to the operating conditions, the cooling system is switched off because the temperature of the intermediate fluid in the tank is sufficient to keep up with the performance of the drying process. Energy saving due to the mechanical compressor stop of the refrigeration system is an advantage in this type of dryer.

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6. Refrigeration dryer according to type of condensation

Once the refrigerant fluid in a refrigeration circuit has been compressed, it must be liquefied by reducing its temperature by means of a refrigeration condenser in order to restart the compression refrigeration cycle. The temperature reduction is achieved either by using ambient air or water from a cooling tower or an air cooler.

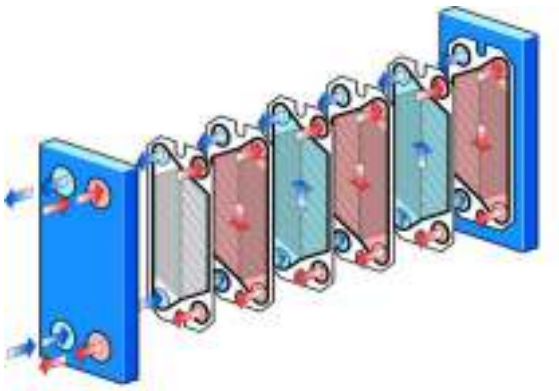
Air condensation refrigeration dryers are those in which the refrigeration system's condenser is built using a coil of copper tubes and aluminium fins, where a fan forces the ambient air through it to cool the cooling fluid. In turn, water-cooled refrigeration dryers are those in which the refrigeration condenser is a shell and tube or plate type heat exchanger through which water circulates to cool the refrigerant.

The choice of one or another type of cooling condenser will only depend on the availability of water and/or ambient conditions. However, it is always recommended to use a water condensation refrigeration system as it has a greater stability and performance than ambient air condensation.

7. Refrigerating dryer according to exchanger construction

Plate or multi-tube heat exchangers not only define a refrigeration dryer constructively but also its characteristics and performance.

Refrigeration dryers with plate heat exchangers:



- ✓ Ecological refrigerant.
- ✓ Stable dew point.
- ✓ No losses of compressed air.
- ✓ Higher energy efficiency due to high turbulence generated in the ducts
- ✓ they are more efficient, so less exchange surface is required, making the dryer more compact and lighter.
- ✓ The high energy efficiency of the plate exchangers allows the target temperature to be achieved with the least amount of energy.
- ✓ Life cycle from 7 to 10 years.
- ✓ Maximum working pressures around 140 bar.
- ✓ Easy installation and maintenance.
- ✓ Pre-filter required.

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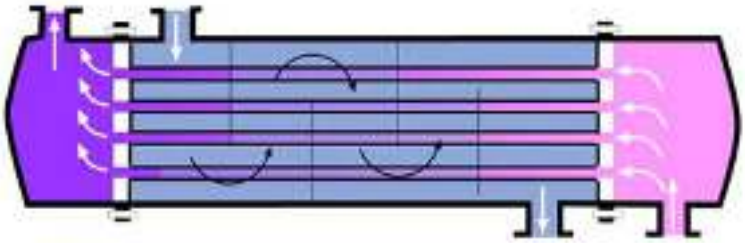
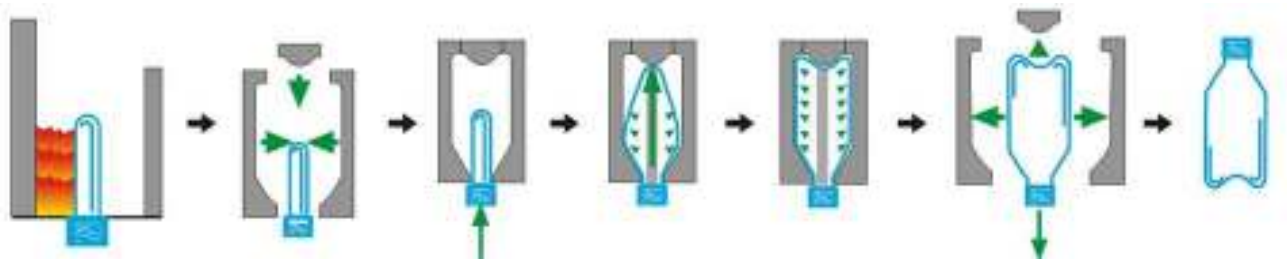
Refrigeration dryers with multi-tube heat exchangers:



- ✓ Ecological refrigerant.
- ✓ Stable dew point.
- ✓ No losses of compressed air.
- ✓ Special designs can be considered in order to have better access to the tube plate and inner tubes for cleaning.
- ✓ Small pressure losses.
- ✓ Low sensitivity to incrustations and soiling.
- ✓ Life cycle of more than 25 years.
- ✓ Maximum working pressures of around 250 bar.
- ✓ Simple installation and maintenance.

8. **Refrigeration dryers for the PET Blowing Industry**

For economic reasons, the use of disposable bottles and containers made of PET is growing strongly worldwide, especially to replace glass bottles. PET packaging is very competitive in energy consumption and waste generation compared to other materials. Thus, PET packaging has become the majority in the market for soft drinks, mineral water, cooking oil and washing-up liquid. The production technology of PET bottles has allowed their optimisation in weight without detriment to the marketing of commercially attractive designs. In the process for the production of PET bottles, plastic pellets are melted and injected under pressure into moulds where the preforms of the bottles are produced. These preforms are heated and introduced into a mould where dry compressed air is injected to inflate them into the shape of the mould and form the container.



- Diagram of PET bottle manufacturing process -

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In order to achieve the characteristic properties of PET bottles, such as high mechanical resistance and transparency, it is necessary compressed air used has a certain maximum amount of water vapour when blowing in the bottle, so that no water vapour interstices are generated inside the material.

- PET Bottle Blowing Machine -

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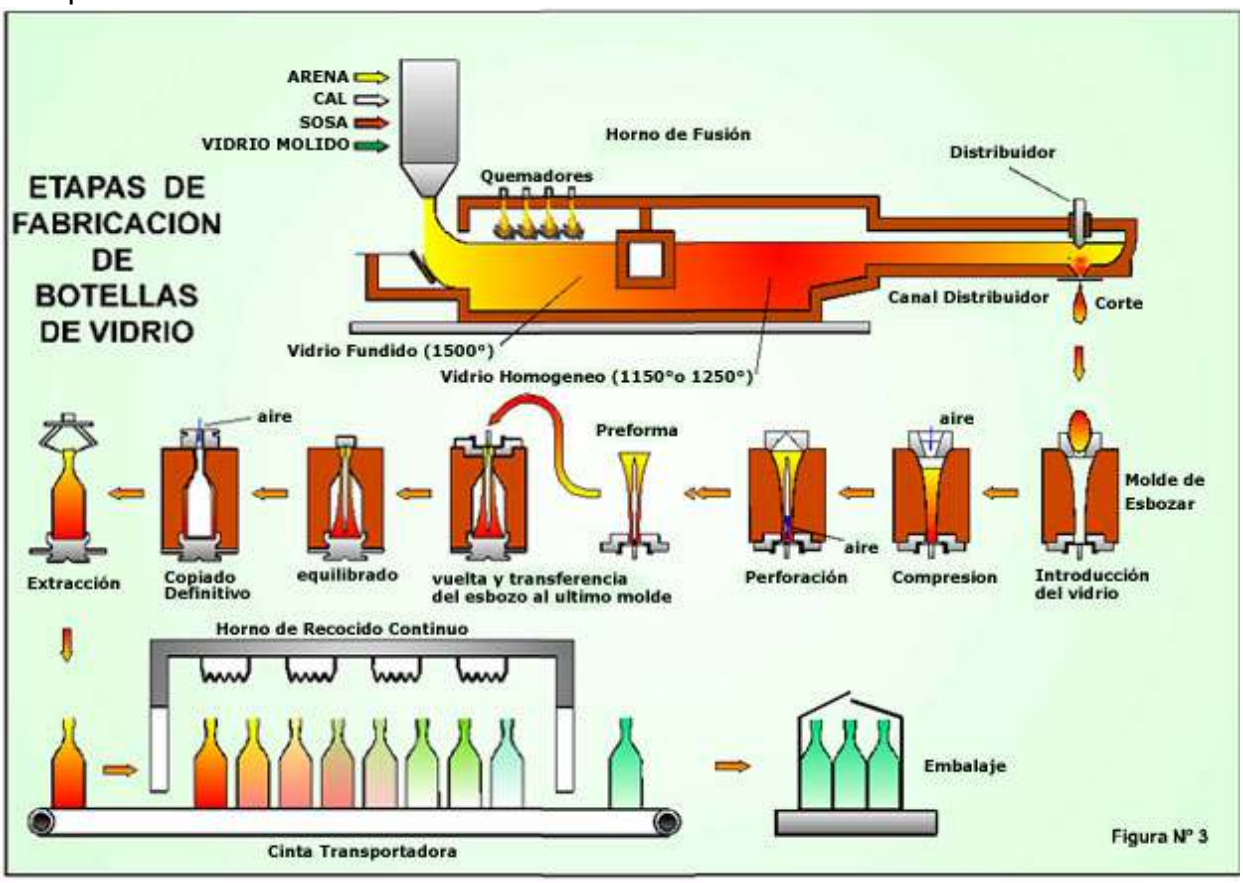
9. Refrigeration dryers for glass industry

Glass is an inorganic product, it has been cooled to a solid state without undergoing crystallisation. The main components involved in the manufacturing process of glass bottles come from nature, exist in large proportions and are easily extracted, ensuring a minimum ecological impact. Furthermore, the technological processes used in the manufacturing process of glass bottles have led to a constant decrease in the extraction of raw materials, in addition to the use of the glass bottle shell (recycled glass) for the manufacture of bottles. The fact of glass packaging can be recycled without losses of quality or quantity contributes to the protection of the environment.



- Diagram of glass bottle manufacturing process –

The manufacturing process of glass bottles begins when the raw materials, including glass bottles from recycling, are mixed and taken to the melting oven at temperatures close to 1000°C. The molten glass is chopped into drops of a weight equal to a bottle and distributed into several moulds, where a succession of pressure processes, pressing and vacuum are used to shape the new bottles. Once the glass bottle has been manufactured, and still at a high temperature, it is placed in an annealing tunnel to avoid the formation of internal stresses due to rapid cooling by means of controlled temperatures. In this way, the glass acquires a higher degree of resistance.

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- Glass bottle moulding machine –

In order to achieve the characteristic properties of glass bottles such as high mechanical resistance and transparency, it is necessary that during the processes of compression and blowing of the molten glass, the compressed air used has a certain maximum amount of water vapour so that no gaps are created inside the material.

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1. **Design characteristics**

Gas Flow:	from 15 to 24000 m^3/h
Gas Temperature:	from 10 to 55ºC(without pre-cooler)
Gas Pressure:	from atmospheric pressure to 200 bar(g)
Construction material:	Carbon steel Stainless steel
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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