

New technology cuts costs and saves space

Exciting new thermal mass technologies are now enabling significant savings to be made when it comes to providing effective refrigeration drying of compressed air for compressor systems delivering up to 34 m³/min - and all housed in a more compact unit design.

There are a number of drying methods available to treat compressed air, the suitability of each depending on the requirements of the specific production process in question. Refrigeration drying is the most common as it delivers sufficient performance and compressed air quality for most uses. However in the past it has been relatively energy-intensive.

Peak values are decisive

In order to reliably provide the required compressed air quality, refrigeration dryers should be designed for continuous performance under the most extreme conditions - even if peak temperature conditions were to prevail 365 days a year. As this is never the case, more energy must be invested in compressed air drying than is required to meet actual demand – unless the dryers are equipped with a technology capable of adjusting their output to actual demand.

When a compressed air system runs at 100 percent of capacity, the process of drying the compressed air accounts for around 3 percent of the systems total energy requirements. However, if the system is only running at partial load, the compressed air dryer will also be running at less than capacity. This is especially unfavourable when production facilities are operating for just one or two shifts, as the dryers are left to dry only the compressed air for smaller consumer points or leaks during periods when production activities are not required.

To ensure reliable compressed air quality it is recommended that compressed air dryers run continuously. However, the more the compressors are running at anything less than full capacity, the greater the energy waste resulting from a compressed air dryer left running continuously 24 hours per day, configured to deal with maximum temperatures. Under such conditions, the energy requirements for the compressed air dryer can spike dramatically and account for up to 20 percent of the total energy required for compressed air production.

Energy optimisation measures

Refrigeration dryers have benefited from technical innovations over the years, including 'digital scroll' coolant compressors and thermal mass dryers, which improved the performance of refrigeration dryers operating with air flow rates of less than 50 m³/min in partial load.

The digital scroll method involved modifying the clearance losses within the scroll compressor used for the coolant, which in turn regulated the flow rate of coolant to adjust it to the quantity required to cool the compressed air. In addition to a scroll compressor to cover the base load, a controlled scroll compressor which was switched off completely during periods of very low demand was employed. The method allowed for a relatively large control range. Unfortunately technical difficulties of implementing it made it less attractive.

Buffer dryers were the preferred technology for compressed air flow rates less than 20 m³/min. Some systems relied on a tank to buffer load fluctuations while keeping the pressure relatively constant and reducing compressor switching to a minimum. This meant the larger the tank, the smaller the pressure fluctuations and therefore, less switching was required. Other systems relied on a thermal mass instead of incorporating a cool air buffer tank.

These dryers generally use mineral materials to store the cooling energy. In order to keep the switching frequency of the coolant compressor within economical bounds and to ensure a consistent pressure dew point, the amount of mass required rises in direct proportion to the system capacity. Furthermore, heat distribution within the thermal mass requires precise regulation.

Thermal mass systems are extremely reliable and involve no mechanical loads or switching of any type of system. Moreover, when the thermal mass is saturated, the system maintains safety reserves in order to accommodate short-term overload periods. However, weight considerations impose certain restrictions, for example thermal mass dryers suitable for even relatively modest compressed air capacities of 17 to 20 m³/min are extremely heavy. Until recently, larger systems had to be equipped with digital scroll systems and were precluded from benefiting from the advantages of thermal mass dryers.

New technology

A new technology which has recently entered the market is a refrigeration dryer equipped with a totally different type of thermal mass – a phase changing material (PCM). Phase changing materials can store and release vast quantities of energy if they are harnessed at the precise point at which they undergo a phase change. These materials work according to the same principle by which ice cubes keep a drink cool. The temperature of the drink remains constant as long as the ice cubes remain melting in the glass. They are capable of absorbing a significant amount of heat before melting completely; consider that the same amount of energy is required to change solid ice with a temperature of 0°C to a liquid as is needed to heat water from 0°C to 80°C.

These thermal masses are also known as latent heat thermal masses owing to their capacity to store thermal energy virtually invisibly for long periods with only minor losses and their ability to accommodate any desired repetition cycle.



Latent heat thermal masses usually employ special salts or types of paraffin as the storage medium since they can absorb huge amounts of thermal energy. When the thermal energy is discharged, the thermal mass solidifies. During this process, the thermal mass returns the large amount of heat it previously absorbed back into the environment. The temperature remains constant during the transition from one state of matter to another as all the heat entering the system is invested in the change of state. These innovative refrigeration dryers exploit the analogous principle of liquefying and solidifying for thermal management purposes.

At a basic level, these dryers function as follows: when compressed air requires cooling, from e.g. a starting temperature of 5 °C, the coolant compressor is switched on. The refrigeration dryer cools the paraffin to a temperature of around 3 °C while the compressed air cools simultaneously. During this period, the temperature remains constant because the paraffin is undergoing a phase change from fluid to solid. The material is then cooled somewhat more, to around 2 °C. The coolant compressor then switches off the supply current. The compressed air then flows into the heat exchanger, which is surrounded by the solidified paraffin, where the air gradually warms the paraffin, which in turn keeps the compressed air cool as it changes from the solid to fluid state. This process continues until a set maximum temperature threshold is reached, at which point the coolant compressor switches on the supply current and the whole cycle begins anew.

These new refrigeration dryers employ a paraffin-based system. This material has a low expansion coefficient as well as 98% better thermal density than the materials previously used as thermal masses.

The higher storage density of the PCM has meant that the heat exchanger in the refrigeration dryer could be completely redesigned. While earlier refrigeration dryers used copper spiral heat exchangers, the first thermal mass dryers relied on plate heat exchangers. However, the new refrigeration dryers work with an aluminium heat exchanger that combines these two heat exchanger systems – an air-air heat exchanger as well as another compressed air-PCM heat exchanger. In addition to energy efficiency advantages, this new dual heat exchanger design has also reduced the space requirement.

Reduced pressure loss, reduced energy requirement

The compact design has allowed pressure losses to be reduced to 0.15 bar in comparison to the 0.20 bar value characteristic of conventional models. The input energy requirements are also exceptionally low, requiring less than 87 watts per m³/min to dry compressed air. Thanks to new, smaller components as well as intelligent component layout, this new technology additionally means that the entire dryer can also be significantly lighter and more compact.

Furthermore, the entire cooling system has been upgraded in these new refrigeration dryers, along with the air heat exchanger. A highly efficient scroll compressor has



replaced the previously used reciprocating compressor and, the capillary tube has been replaced by an expansion valve. Expansion valves regulate the coolant quantities dynamically, depending on the load. As a result, significantly less coolant is required and the coolant compressors can run at a much lower output. Overall, these new dryers require 50 percent less power than comparable conventional equipment.

Gateway to further development

Recent developments serve as a gateway enabling even larger dryers to be equipped with this innovative technology. This will primarily benefit systems in the capacity range beyond the technical limits of thermal mass dryers, for which weight and size considerations have previously made this technology an impractical option. In the coming years even more models with greater capacities can be expected to enter the market.

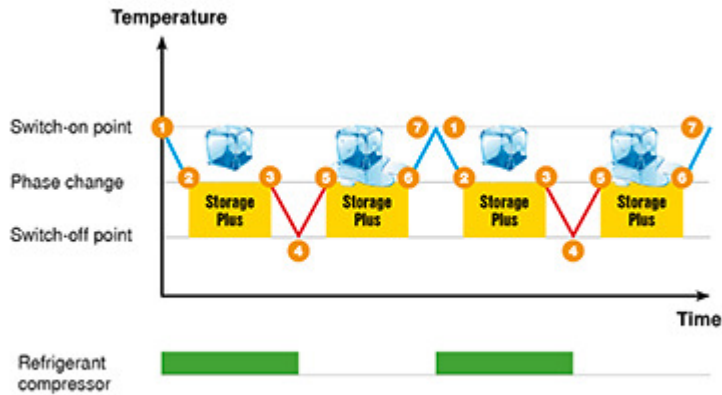
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Innovative new refrigeration dryers are reducing space requirements and drastically cutting energy consumption



How the new refrigeration dryer system works The system functions as follows: 1. Compressor supplies cold coolant to dry compressed air and cool the thermal mass. 2. Thermal mass solidifies, maintaining constant temperature, and channels significant amounts of heat through the coolant. 3. Coolant cools the thermal mass until the switch-off threshold is reached. 4. Coolant compressor switches off. 5. By absorbing heat from the air, thermal mass provides cooling action to dry compressed air. 6. Thermal mass melts, maintaining constant temperature, while absorbing significant amounts of heat from the moist compressed air. 7. Thermal mass warms until a threshold is reached, triggering the compressor to switch on.