DRYING WITH SUPER-HEATED STEAM AT AMBIENT PRESSURE
SYSTEMS FOR ENERGY-EFFICIENT AND MILD PRODUCT DRYING

Drying is an important and frequently used process in various branches of industry. In the production, treatment and processing of solid materials drying is often an essential process step. Drying with heated or cooled air is generally used. In many cases a large part of the energy required in the whole process chain is used for drying. Furthermore, these processes often require a long residence time and therefore considerable space. Using super-heated steam as atmosphere in the dryer offers significant advantages to improve drying processes in terms of dwell time, energy consumption and other parameters.

The concept

The product material to be dried is exposed to an atmosphere of super-heated steam. The product material is heated and releases its moisture as steam. The loss of evaporation heat energy cools down the steam. The volume of steam atmosphere is controlled and surplus steam is taken out of the process. The lost heat energy is returned to the steam atmosphere to maintain the process temperature. The operational temperature is generally 120 °C to 180 °C in standard applications, but could also be higher. Due to the difference in density between air and steam, the steam atmosphere forms a stratification layer and seals itself. No sealing installations such as sluices are required. Therefore, any conveying system, such as belts, spirals or drums, can be chosen that is best suited to the transport handling of the product.

Effects and advantages

In terms of drying properties super-heated steam is different to air. The values for heat capacity and heat transfer are much higher, which results in a significantly faster drying process with a shorter dwell time. Because of the pure steam atmosphere and its low viscosity a fast diffusion and flow velocity of the gas to and into the product is possible; this has a positive impact on the short process time, but also results in a more homogeneous drying. Due to these effects, dryers based on this principle can be designed to be more compact and with lower investment costs compared to air-based dryers. A further consequence of the low process times is that heat losses are lower, which means less energy consumption and costs. Basically, it is feasible to use the surplus pure steam with its energy content for other purposes in a facility. In such a case high overall energy efficiency can be achieved in an industrial facility. Steam compressors can also be used to raise the specific enthalpy and thus the temperature once again to an interesting level.

On the other hand, the steam can be condensed and be used as demineralized water. In some cases, other volatile compounds such as aromatic substances or volatile organic compounds (VOCs) are evaporated together with the steam. Standard processes permit condensing them separately and recovering them as a valuable product as for example from various agricultural fruits. Due to the internal circulation of the steam as a drying medium and the sealed housing, no waste air treatment is required. The pure steam with no oxygen present provides an inert process atmosphere in the dryer, which prevents oxidation of the product. A further advantage...
of the inert atmosphere is the reduced risk of explosion e.g. by dust. To enable super-heating of the steam atmosphere the temperature has to be about 120 °C. This leads to a hygienization of the product. The short dwell time due to the highly efficient drying process results in a low rate of degradation of product compounds, especially in food products.

**Reference data**

**Mineral raw materials**
When drying a bulky material a reduction in process time of 30 percent compared to the existing hot-air dryer was achieved. Besides the reduction in heat losses, this permitted a reduction of the overall size of the dryer by one third or a corresponding increase of the throughput capacity.

**Drying of construction material**
It was possible to reduce the process time from 4 to 6 hours down to less than 3 hours in first test trials on a continuous laboratory dryer. This led to an increase in process capacity of 25 percent to 50 percent (with an additional significant saving of specific energy consumption).

**Foodstuffs**
In this field of application drying is a key process. Significant savings on time and energy have been achieved too. For example, in drying of apple chips dwell time was reduced from approx. 8 hours down to 50 minutes without any loss of product quality. In the case of drying a pre-processed food product based on potatoes the drying time was cut by 90 percent from approx 7 hours to 30 minutes.

**Fodder and pet food**
When drying pet food and animal fodder, the dwell time has been reduced from 35 to 10 minutes. In this case the drying process was operated at 10 °C lower than the currently employed hot-air drying process. Accordingly, the savings in specific energy consumption were significant too.

**Hygienization**
Based on systematic test trials it has been shown that the process of super-heated steam drying is well suited to the hygienization of foodstuffs, for example. The specific and controlled contamination of mushrooms and paprika with *E. coli* cells and *Bacillus* endospores has been reduced by a logarithm factor of 7.
Our services

- Scientific characterization and specification, research on tasks related to drying and heat transfer
- Development of specific drying process concepts according to the customer’s individual needs
- Layout and specification of process by an interdisciplinary team with background of process engineering, design, chemistry, microbiology and electrical engineering
- Laboratory plants for test trials
- Product related analysis of the drying process using a wide range of analytical equipment and expertise
- Design specification of process unit and components, e.g. by integrated combination of 3D CAD design and numeric modeling of fluids, heat transfer etc. with latest software
- Supporting our clients from first test trials to commissioning of a plant. If partial or turn-key delivery of the construction is required, we co-operate with a network with qualified industrial suppliers.