SUMMARY

After a two-year development period Allgaier Process Technology presents a new TK-D combined rotary drum dryer/cooler based on the Mozer system. This dryer/cooler makes it possible to cool the previously dried solids down to particularly low temperatures close to the ambient or cooling air temperature. It is characterized by a very high energy efficiency as well as heat recovery by separate recycling of the exhaust air from the cooler or by evaporative cooling. It is particularly maintenance-friendly due to its single-shell design. Special designs are suitable for combinations of counter-current treatment, heat treatment, calcining or reaction control as well as for subsequent cooling in a single mechanical unit.

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1 Introduction

Allgaier rotary drum dryer/coolers have a worldwide reputation as high-grade, powerful and efficient drying and cooling systems. They are used, in particular, for processing free-flowing bulk materials but also for sticky, lumpy or severely abrasive materials [1, 2]. The individual task-based design and manufacture of the rotary tubes that are traditionally referred to as drums as well as special designs facilitate a wide range of applications for throughputs from 1 to over 350 t/h (Fig. 1).

Many dryers and combined dryer/coolers based on the Mozer system are used in the mineral materials industry, in the sand-stone-earth industry and in mining. Allgaier uses special solutions to cover not only convective methods but also technological processes for calcining as well as for indirect heating, drying and cooling extending to coating and granulation [5].

The new TK-D rotary drum dryer/cooler is a further development of the previous, and already successful, TK and TK+ series of Allgaier dryer/coolers that can cool the product to about 50 to 60 ºC [3]. Particularly low temperatures of, for example, 30 to 45 ºC or close to the ambient temperature or that of the cooling air, are being demanded increasingly for the dry output materials in some applications – such as for foundry sands, for the production of ready-mixed products (e.g. construction adhesives) or for the processing of materials for further treatment stages in recycling processes.

2 Single-shell rotary drum design

The previous familiar dryer/coolers combinations have been designed as double-shell rotary drums in which the drying takes place in the inner tube and the cooling in the outer tube. However, in the new TK-D series the drying and the cooling of the solid material is made possible by a single-shell construction of the rotary tube with separate areas for the drying and cooling. This means that, in contrast to double-shell rotary dryer/coolers type TK, inside the single-shell dryer/coolers Type TK-D there are no areas of contact between the dry material in the cooler section (outer drum) and the hot outer surface of the inner drum (drying section). Fig. 2 illustrates the basic operating principle of the new TK-D rotary drum dryer/cooler.

The new TK-D series has a specially designed central area that allows the exhaust air from the drying and from the cooling to pass through the rotary drum shell. At the same time it ensures that the dried solid material is passed very rapidly from the drying zone to the cooling zone without falling out through the openings in the drum wall for discharging the exhaust air. After the hot solid material has passed through the central area and into the cooling zone it is cooled in counter-current and leaves the rotary drum through a solids outlet in a dry and cooled state (Fig. 3). The exhaust air from both the drying and the cooling is dedusted in a downstream bag filter.

The hot, previously dried, products are routinely cooled by ambient air to temperatures down to about 10 K above the environment but it is also possible to achieve temperatures of the solids of down to about 10 ºC by using air that may optionally be precooled. The ambient air or conditioned cooling air is introduced via the same casing through which the solids are also discharged. It is particularly advantageous that the length of the cooling zone can be designed for optimum cooling effect completely independently of the length of the drying zone.

3 Recirculation of exhaust air and heat recovery

The central area, which may be divided into two parts by a dividing wall, has a configuration that allows the product to pass through from the drying zone to the cooling zone so that the two streams of exhaust air can also be removed and dedusted separately. The moisture-laden dryer exhaust air is discharged into the atmosphere after it has been dedusted.
but the dry, dedusted, exhaust air from the cooler can be recycled to the process as preheated drying air (Fig. 4).

The heat recovery achieved by recycling the exhaust air, which can be combined optionally with evaporative cooling to assist the cooling, leads to a further increase in the efficiency of the cooling process and therefore to additional energy saving when compared with previous configurations. The evaporative cooling is achieved by secondary evaporation of some of the residual moisture in the cooling zone, which results in evaporative cooling of the solids.

### 4 Special processes

The separate introduction and removal of the air flows also permits different process control of the solids and the air. This means that either co-current or counter-current drying can be combined independently of one another with counter-current or co-current cooling.

In particular, the possible counter-current routing of the hot gas and solids is suitable for various special types of high temperature treatment, such as the calcining of solids followed immediately by cooling. The hot gas is directed into the connection in the casing in the central area that, in the standard design, is used for drawing off the drying air. The used hot gas is then drawn off next to the solids input. Here again the hot exhaust air from the cooler can be used, with or without dedusting, as preheated combustion air for the hot gas generator (Fig. 5). This achieves a significant saving in fuel.

### 5 Ease of maintenance

Mineral materials, such as quartz sands or slags, are well known for their particularly abrasive action on the equipment walls and, in particular, on the internal fittings in the dryer/cooler. Designs that make for ease of maintenance and repair are therefore needed specifically for abrasive products.
15. TÇMB International Technical Seminar & Exhibition
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15. TÇMB International Technical Seminar & Exhibition
15th TÇMB International Technical Seminar and Exhibition will be held in Kaya Palazzo Golf Resort Belek, Antalya, Turkey between 8th and 11th October, 2019.

The program is open for both national and international attendees from cement industry, service and technology providers. The event is important for the manufacturers to follow up the recent developments and creates an opportunity for the participants to consider the new investments while having a chance to benchmark their business for every two years.

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ALL THE BOOTHS ARE SOLD OUT, THANK YOU FOR THE INTEREST. YOU CAN STILL BE THE PART OF THIS EVENT
The TK-D rotary drum dryer/cooler is particularly maintenance-friendly because of its single-shell design. It is very simple to walk through the complete length of the rotary drums, which usually have large diameters, both for inspection purposes and for maintenance or any necessary repairs. In the new series there are no inaccessible areas of the dryer. Generously dimensioned maintenance openings are provided at safely accessible points on the rotary drum itself as well as on the dryer casing for inspection and maintenance. This means that worn internal fittings and any areas of the rotary drum that may have been affected locally by wear can be quickly discovered, repaired, replaced or optimized to increase production or in the context of a product change (Fig. 6).

6 Experimental procedure and dryer design

The design of industrial drying plants usually requires trials on a pilot plant scale. The parameters that are determined, such as residence times, temperatures, air and gas flows, achievable water evaporation rates and degree of drying of the end products, are then used for the individual plant design. This allows the manufacturer to offer comprehensive guarantees with respect to agreed plant performance, energy consumption and product properties. Allgaier has a well-equipped research centre at the company location at Uhingen with a large number of test plants for all the processes and machinery in the supply programme.

Trials in laboratory plants that are too small can lead to uncertainties during the scale-up so all the pilot plants are purposely designed on a semi-industrial scale (Fig. 7). This means that representative trials can be carried out under realistic conditions.

During the design of rotary drum dryers the test results that have been determined are combined with thermal balance calculations with the inclusion of a great deal of experience from similar plants that have already been supplied [4, 5]. It is becoming ever more important that a plant is designed as accurately as possible in order to conserve energy and resources and be competitive in the market.

After the important operating parameters, such as temperature of the air and solids, gas velocity and burner output as well as mass flows of the solids and hot gas temperature, have been calculated using a thermal balance it is possible to determine the dryer volume and therefore the length and diameter of the rotary drum via the empirical parameter of the specific water evaporating capacity $\omega$ (evaporated water/m$^3$).
The specific water evaporating capacity \( \omega \) expresses the ability of a dryer configuration to evaporate a certain quantity of water per m\(^3\) of drum volume as a function of the chosen hot gas temperature. The parameter represents an empirical value that has been obtained from numerous plants supplied for the particular application and type of product. It is particularly dependent on the specific and optimum configuration of the internal dryer fittings but also on the product and on the material moisture level to be achieved [4].

\[ \dot{Q}_{\text{tot}} = \dot{m}_L (h_{1+x})_a - (h_{1+x})_L + \dot{m}_P (h_{Pr,a} - h_{Pr,e}) + \dot{m}_F (t_{a,\text{real}} - t_{\text{amb}}) + \dot{Q}_r \]  

\[ \dot{Q}_{\text{tot}} = \dot{m}_L c_F (t_e - t_{\text{real}}) \]  

\[ P_b = \dot{m}_L c_F (t_e - t_{\text{amb}}) \]

Figs. 9 and 10 illustrate the dependence of the solids capacity and water evaporating capacity (Fig. 9) and of the specific fuel requirement (Fig. 10) on the material inlet moisture content. This is based on the example of the drying and cooling of sands using a plant with a nominal dry material capacity of 30 t/h with an assumed solids input moisture content of 6% at the point of design. The example deals with sands that only contain surface moisture.
An appropriate dryer is also capable of drying sands with higher initial moisture contents but the solids throughput (moist and dry = upper lines in Fig. 9) falls with increasing initial moisture content. With falling initial moisture content the solids capacity (feed) can be increased to about 41 t/h. However, with a further reduction in initial moisture content to less than 4.5 % the solids capacity remains at the maximum value of the so-called mechanical limit because of the limited transport capacity of the rotary drum internal fittings that have been optimized for this case and the limitations of the dryer drive. The lower line in Fig. 9 represents the water evaporating capacity which, because of the maximum stalled burner capacity, remains constant above the nominal initial moisture content of the sand (point of design) but falls at low initial moisture contents and constant quantity of solids.

As a result, the specific gas consumption relative to the throughput of dry material rises with the initial moisture content of the sands being treated. The three virtually parallel lines of the specific gas consumption in Fig. 10 characterize the difference in energy requirement with and without evaporative cooling [3] through counter-current routing of the solids to be cooled and the cooling air in the cooling zone of a TK-D dryer/cooler (the upper two of the three lines in Fig. 10) or with evaporative cooling and additional recycling of the hot exhaust air from the cooler (the lowest of the three lines in Fig. 10).

In the given example the saving in fuel through evaporative cooling when compared with cooling without evaporative cooling lies in the range between 5 and 20 %, depending on the initial moisture content. Further savings of the order of about 5 to 10 %, depending on the initial moisture content, can be achieved by additional separate removal of the exhaust air and recycling of the hot dry exhaust air from the cooler as preheated combustion and process air (s. Fig. 4). This means that, in total, there are possible fuel savings of around 16 % at the point of design.

A new test plant (Fig. 11) was built during the development phase of the TK-D rotary drum dryer/cooler. The total length of the rotary drum is 6.7 m with a diameter of 710 mm. The detailed configuration and arrangement of the internal fittings (“lifters”) that are important for efficient material and heat exchange can be adjusted extremely flexibly in this test plant to suit the requirements of the particular process and the specific flow behaviour of the particular bulk material. The test plant was exhibited at the bauma in Munich in April 2019 and is now available to any interested parties for carrying out trials at the Allgaier research centre.
The balance equations shown above were supplemented with the cooling air flow, which permitted analogous re-calculation and evaluation of the trials with the new TK-D system.

7 Practical applications

The new rotary drum dryer/cooler has already proved successful in various industrial applications. Fig. 12 shows a plant installed for a European customer for drying and cooling slag during metal recovery. The rotary drum has a total length of 12 m and diameter of 1600 mm. The extraction casing in the central area is clearly visible.

For an initial moisture content of the slag granules of about 8 % with a particle size range of 0 to 20 mm the solids are dried at a throughput of 8 t/h to residual moisteres < 1 % and then cooled to an output temperature of about 50 °C. Water evaporating rates of up to 800 kg/h are achieved. The product is therefore optimally suited for subsequent sorting process stages leading to final storage. One important reason for the customer’s decision in favour of the TK-D system was the good inspection and maintenance facilities.

In another application for a dry building materials plant in Latin America natural sand with particle sizes of 0 to 3 mm and initial moisture levels of around 5 % are dried to residual moisteres < 0.4 %. The subsequent cooling takes place to temperatures between 40 and 50 °C, depending on the current ambient air temperature of between 20 and 35 °C. These low temperatures required by the customer for the dried material, even at high ambient temperatures, were one of the main reasons for the customer’s decision to purchase the new TK-D dryer/cooler. The machine’s rotary drum has a total length of 13 m with a diameter of 2000 mm. Solid throughputs of up to 30 t/h are achieved. Fig. 13 shows the rotary drum during manufacture.

8 Final comments

The new TK-D rotary drum dryer/cooler provides the opportunity for efficient drying of free-flowing bulk materials followed immediately by efficient counter-current cooling. The two process engineering operations of drying and cooling take place in a single rotary drum, which provides very good conditions for inspection, maintenance and repairs. A specially designed central area for passing the dried solids into the cooling zone facilitates the efficient recycling of the hot exhaust air from the cooler as preheated drying air as well as special designs for calcining or reaction control. The recirculation of the exhaust air and optional evaporative cooling make the process energy-efficient. Reliable plant design is ensured by decades of experience and the option of carrying out realistic trials in a flexibly configurable test plant.

LITERATURE