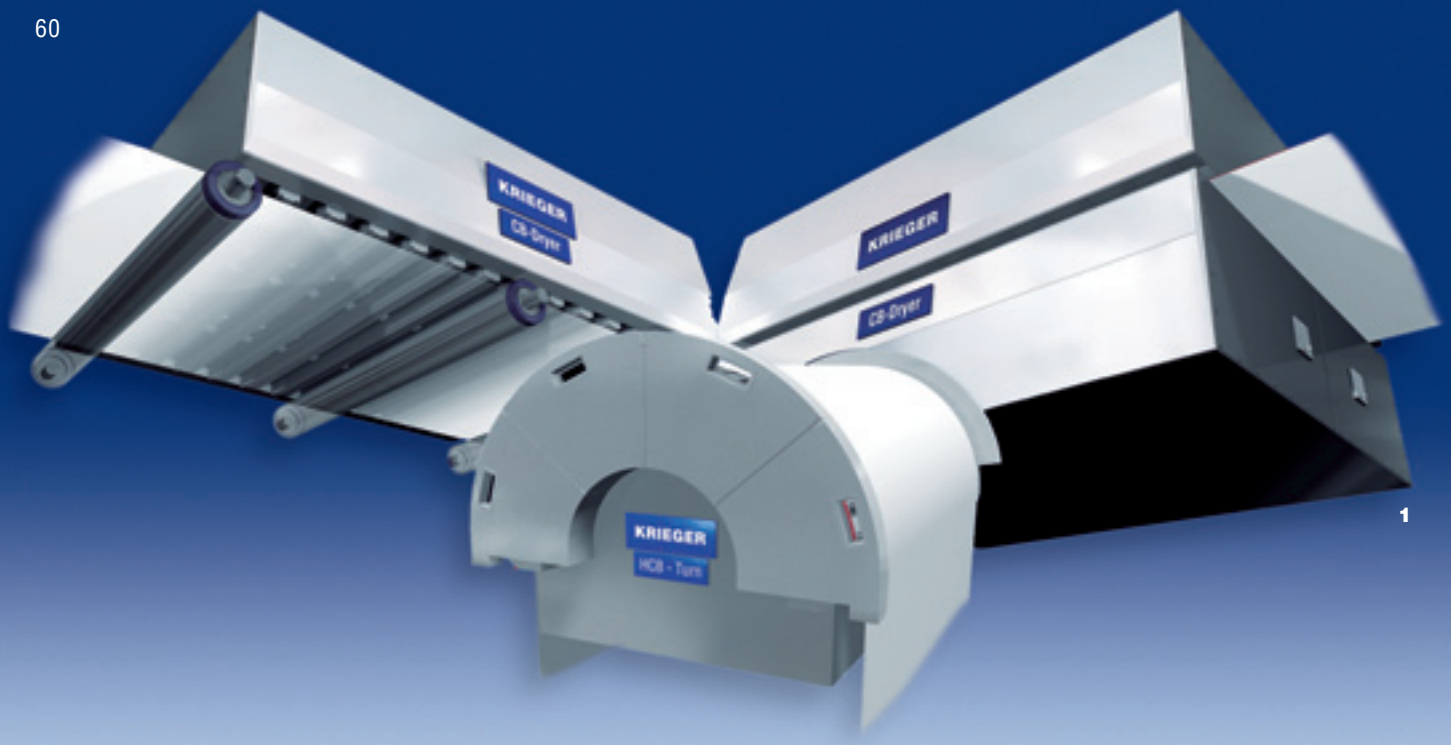

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Development trends in non-contact web drying systems

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Due to rising production speeds and quality requirements, drying systems and concepts for non-contact drying of paper and coating color are increasingly being customized depending on their application. At the same time, high energy efficiency, trouble-free web guiding and low life-cycle costs must be ensured.

For many years, Krieger has been the only system supplier worldwide to provide a complete range of products for non-contact drying. Thanks to our own intensive development work and constant exchange of ideas and experience within the Voith Divisions, optimally matched system configurations are guaranteed. In an effort to increase energy efficiency, Krieger's range of products includes gas-fired and electric infrared systems, as well as different types and combinations of hot-air dryers for both drying methods.

While the development of gas-fired infrared dryers is geared toward the utilization of new materials and the simplification of maintenance work, Krieger's activities in convection drying are focused on increasing the performance and efficiency of the systems – as well as optimizing the web run (Fig. 1).

With the modular system designed by Krieger, the following features can easily be adapted to individual applications:

- Fuel (gas, steam)
- Maximum operating temperature (up to 450 °C)
- Nozzle supply air velocity (up to 70 m/sec)

Fig. 1: *One-sided CB-Dryer, HCB-Turn and double-sided CB-Dryer.*

Fig. 2: *Comparison of heat transfer coefficients in hole-type and slotted nozzles.*

- Number of nozzles
- Nozzle spacing/nozzle width
- One-sided dryer or double-sided floating dryer
- Non-contact drying with simultaneous web turning (HCB-Turn).

Consequently, any quality requirements relevant to the user can easily be incorporated during the project engineering phase. In this regard, the following aspects should be given special attention:

- Level of heat transfer and drying rate
- Avoidance of web overheating
- Stability of the web run
- Minimization of the open draws
- Energy efficiency.

Krieger CB-Dryers as components in coating color drying

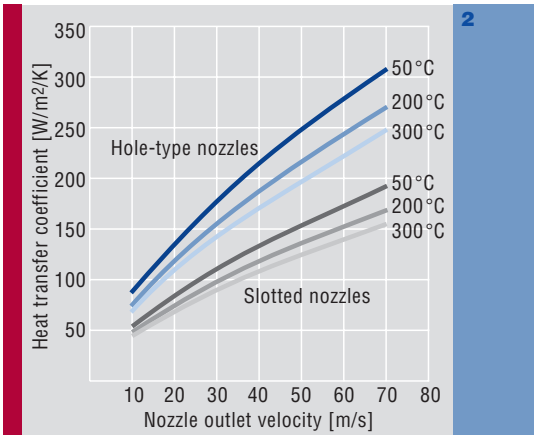
In many cases, a combination of infrared dryers, air dryers and drying cylinders is suitable for coating drying. The function of IR dryers is to heat the web to a high temperature as quickly as possible and simultaneously cause the evaporation of as much of the water contained in the coating as possible. Depending on the coating formulation, by incorporating a large percentage of IR drying, web temperatures can reach over 100 °C in the course of coating drying. For this reason, Krieger prefers to use air dryers from our series of CB-Dryers at this point in the installation, because they allow for comparatively high drying rates at lower web temperatures.

Next, the drying cylinders finish the remainder of the drying with the simultaneous possibility of correcting the curl of the paper or board web.

With our different types of CB-Dryers, Krieger offers a modern air-drying system which, in addition to a uniform, non-contact web run, features highly efficient heat and mass transfer and maximum thermal stability. One of the main features of the Krieger CB-Dryers is the CB2 hole-type nozzle, which permits the highest possible heat transfer rates. The development of this highly effective nozzle type is based both on fundamental insights into flow mechanics and on many years of experience in dealing with the special requirements of the paper industry.

The development of the CB2 nozzle, therefore, aims not only at ensuring maximum heat transfer to the web, but also at obtaining optimized load capacity. In addition, it achieves the highest possible insensitivity to thermal deformation and contamination by coating color during sheet breaks.

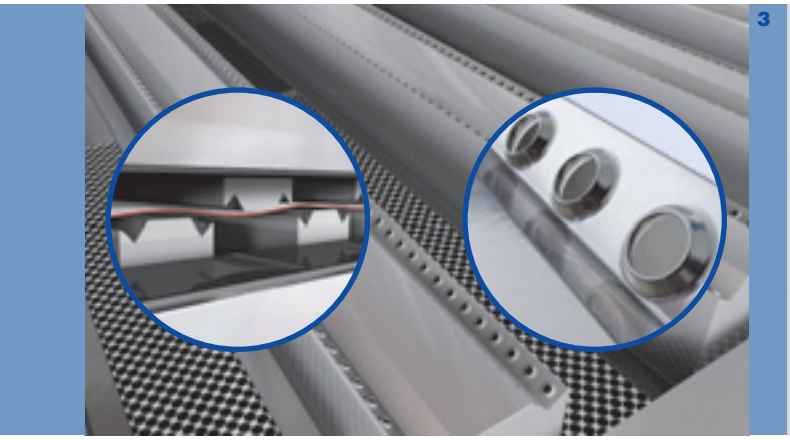
If air is blown onto the paper surface at a suitable angle at high velocity, vortices form in the air, thoroughly blending the drying air. This causes an increased heat exchange between core flow and paper surface. A measure of the number and intensity of these vortices, and thus also of the intensity of the heat transfer, is the so-called degree of turbulence. In addition to the air velocity and the direction of the approaching air flow, the nozzle shape is of major importance for the level of the degree of turbulence. Scientific studies have shown that hole-type nozzles have a distinct advantage over the simple, slotted nozzles. With the same air-flow rate (and the same required heating and fan capacity!), hole-type nozzles achieve up to 50 % higher heat transfer rates than slotted nozzles (**Fig. 2**).

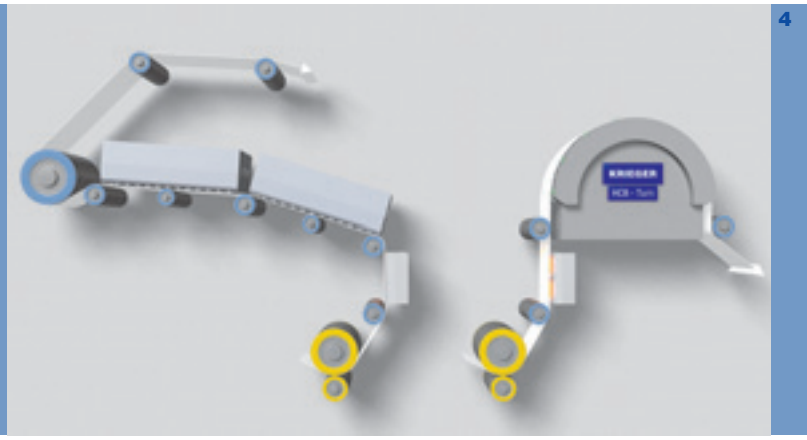


Furthermore, the CB2 nozzle ensures homogeneous heat transfer since, unlike slotted nozzles, a thermal change in the nozzle geometry is impossible. Through the use of materials with relatively low thermal expansion coefficients, a high

Fig. 3: *Schematic of air flow of the CB2 nozzles.*

Fig. 4: *Web run concepts for drying the bottom side of the web.*
Left without HCB-Turn
– long web run
– motor driven rolls
– risk of contamination.
Right with HCB-Turn
– short web run and simplified tail threading
– fewer rolls
– low risk of contamination.





thermal stability of all CB-Dryers used is guaranteed.

Another feature of the CB2 nozzle is the special geometry of the air nozzle. The nozzle outlet openings, placed opposite to each other, generate an extremely stable cushion pressure and, due to the recessed arrangement of the holes, contamination is nearly impossible. As a result, downtime is greatly reduced (**Fig. 3**).

In the CB-Dryer, the largest portion of the drying air is recirculated, whereby the drying air repeatedly makes contact with the web. This results in the transfer of more energy (energy efficiency). A certain portion of the air must, however, be continuously withdrawn from circulation in order to remove the steam that is being created. In the combination of CB-Dryers and infrared systems, the energy balance of the entire system can be optimized through the partial recovery of the energy that is present in the combustion exhaust gases of the gas-fired IR emitters.

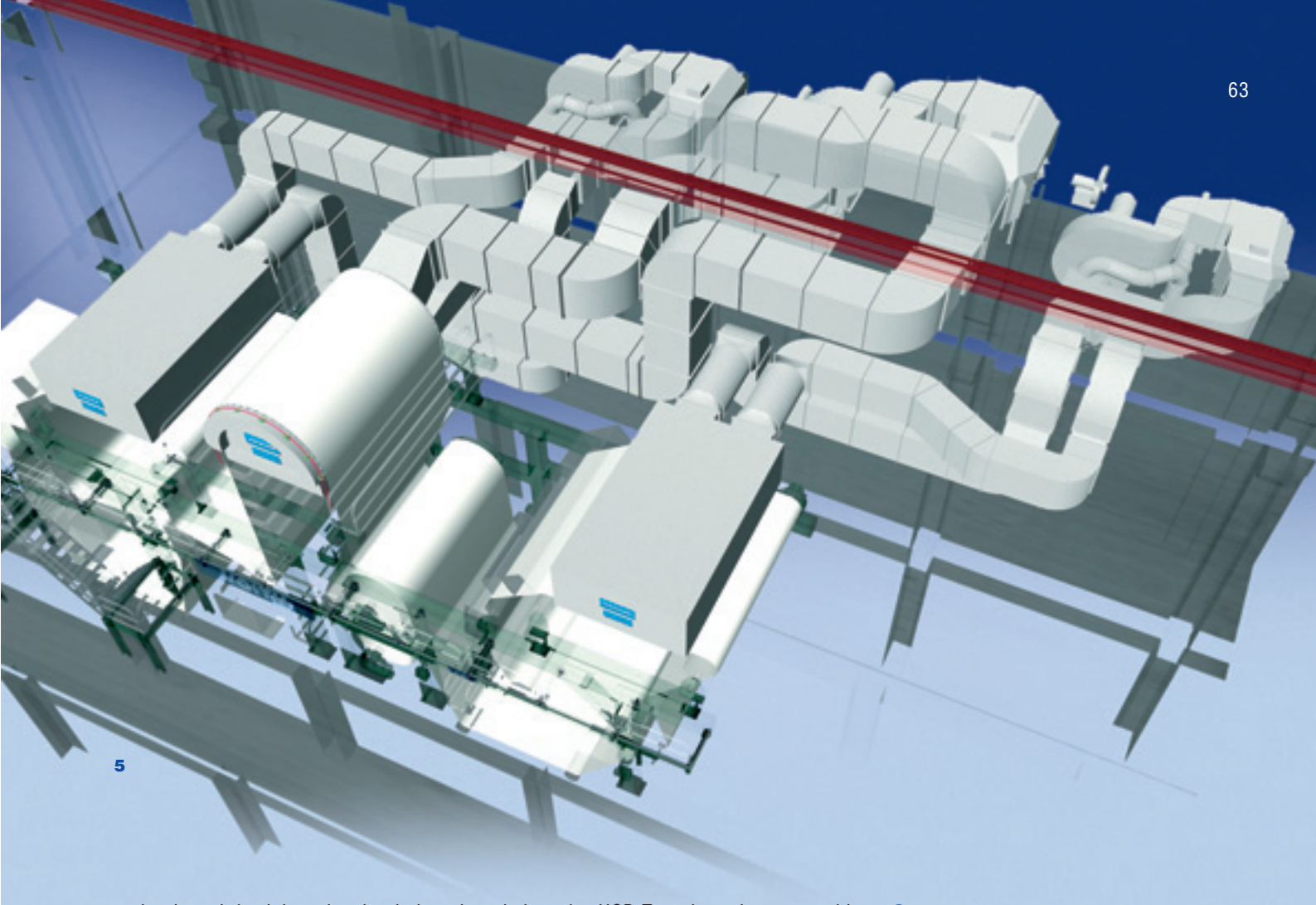
The Krieger HCB-Turn for simultaneous turning and drying of a paper web

The Krieger HCB-Turn has been developed in response to persistent market demand concerning space requirements and web run, – both in the case of rebuilds and new installations, and recently went into operation.

The construction of the HCB-Turn is based on our experience with the above-mentioned excellent characteristics of the CB2 nozzle – which, for many years, has been used successfully in the Krieger CB-Dryer – and the optimized load-carrying capacity of the Krieger CB-Turn. Our challenge was to combine the high load-carrying capacity (turning of a paper or board web by 180° with high web draws) and high drying rates with simultaneous space-saving web guidance (**Fig. 4**).

In extensive trials, the ratio of the width of the supply-air nozzle beam to the width of the exhaust gap in particular, was optimized and a patent is pending for this design. This feature ensures a high exhaust capacity even at high web draws, as is frequently the case in board production. It also results in uniform drying across the entire web width (**Figs. 5-7**).

In non-contact web-turning systems, a certain amount of the air invariably escapes from the area of the cushion pressure into the atmosphere. In order to achieve the required high drying output, the air has to have a high temperature. Krieger has developed a suction system that recaptures a portion of this heated air on both drive and tending sides and



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recirculates it back into the circulation-air system. A patent for this system is pending. The operation of gas-fired systems generates temperatures of approximately 350 °C. In order to avoid overheating of the rope-pulley bearings, an additional cool-air duct has been integrated into the tending-side exhaust system.

In web widths greater than 6 meters, it is often necessary to plan for more space below the HCB-Turn in order to provide room for additional drying components (e.g. infrared dryers). For this reason, Krieger developed an additional model that splits the HCB-Turn with a wrap angle of 180° into two separate parts each having a wrap angle of 90°. In order to stabilize the straight section of the web between the two 90° HCB-Turns, it is equipped with heated CB2-nozzles as well.

Summary

When it comes to the optimization of application-related performance in coating drying, Krieger CB-Dryers and HCB-Turns are important components, especially in combination with other non-contact drying systems (infrared). As a rule, only the suitable combination of systems leads to the desired level of performance and quality. Each application, therefore, requires an individual solution.

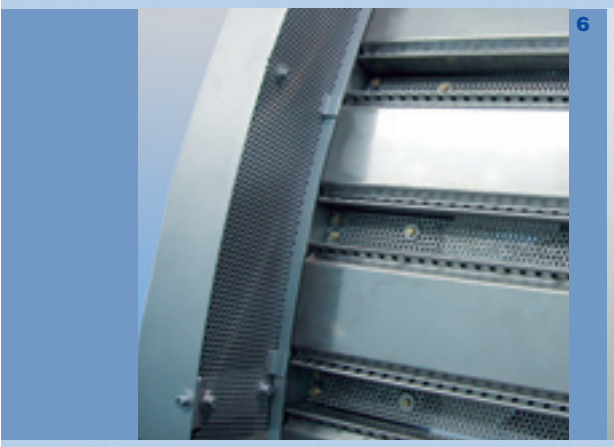

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Fig. 5: *Online coating system with two CB-Dryers and HCB-Turn.*

Fig. 6: *Additional tending-side air return.*

Fig. 7: *Support-nozzle geometry and air-cooled rope pulleys.*