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Recent Improvements in the Kumera Steam Dryer

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Abstract – During the past twenty years steam drying has become a prominent technology for drying of non-ferrous metals concentrate. This is mainly because of its low energy consumption and very low emissions.

The first applications of significant capacity were stationary steam dryers, which however, faced severe challenges in maintenance costs and availability. That technology was soon replaced by Kumera's rotary steam drying technology, which has been the dominant technology in new dryer installations world-wide for the past ten years, ever since the first installation in Hamburg in 1999.

There are ten Kumera steam dryers in operation today and five more to be commissioned during 2011. Practically every dryer is different owing to continuous development, new innovations and operational experience with continuous feedback from the operators.

Most significant improvements relate to capacity increase with the Kumera steam-dryer family, new feeder systems at the wet end, a completely new design of the dry material discharge with increased availability, heating element design and material selection, and control systems. This paper discusses the modifications and improvements introduced which have enabled the Kumera steam dryer to become the global leader in new dryer installations.

INTRODUCTION

Steam dryer technology started to be widely applied for drying of non-ferrous metals concentrates from the mid-1990s. Most applications of that time were stationary steam dryers, which, however, suffered from severe wear that resulted in limited availability and increased maintenance costs.

By the mid-1990s Kumera Corporation made a strategic decision to focus on steam drying, which was seen as a future technology with significant energy and environmental benefits, like 10–20% lower energy consumption, no combustion of fossil fuels, hence zero CO_2 emissions combined with cost-effective gas cleaning and very low dust emissions. In order to achieve this, decades of experience with rotary drum dryers was utilized to overcome operational drawbacks associated with stationary steam dryers.

Experiments and cooperation with the Helsinki University of Technology resulted in construction and thorough testing of a large pilot-scale steam dryer.

These tests eventually convinced Kumera Corporation as well as the first customer about the benefits of this new technology.

Currently Kumera Corporation is the established market leader in new dryer installations with an average of one-to-two new dryers every year. Currently there are eleven Kumera steam dryers in operation in Europe and Asia, with a number of new installations due to take place during 2011, all in China. References with main dimensions are presented in Table I.

Table I: Reference list of the Kumera steam dryers

Installation Year	Site Smelter	Country	Size Ø x length (m)	Initial Capacity, Wet (t/h)
1999	Hamburg	Germany	3.75 x 9.0	82
2001	Pirdop	Bulgaria	3.75 x 9.0	90
2001	Pirdop	Bulgaria	3.75 x 9.0	90
2003	Toyo	Japan	4.44 x 10.14	160
2004	Hibi Kyodo	Japan	3.75 x 9.0	80
2006	Yanggu	China	4.44 x 10.14	160
2006	Jinlong	China	4.44 x 10.14	160
2006	Guixi	China	4.44 x 10.14	160
2007	Harjavalta	Finland	4.44 x 10.14	136
2008	Onsan	Korea	3.90 x 10.14	125
2010	Zijin	China	4.44 x 12.33	180
2011	Tongling	China	4.44 x 12.38	180
2011	Tongling	China	4.44 x 12.38	180
2011	Zhuzhou (Pb)	China	3.375 x 11.5	82

All reference copper smelters in Table I apply flash smelting together with a heat-recovery system in a waste-heat boiler. Therein, a part of the exothermic chemical energy from sulfide smelting is recovered in the form of steam, which is further utilized as a heating medium in steam drying. Consequently, there are no CO_2 emissions related to steam drying.

Typical initial moisture contents of wet copper concentrate range from 8 to 10%, while the target residual moisture content ranges from 0.2 to 0.3%.

The highlights of continuous development, modifications and new designs of the Kumera steam dryer through all fourteen references are discussed in this paper.

EXISTING REFERENCES

Hamburg, Germany, 1999

The first unit was installed in the city of Hamburg in Germany in 1999. The existing conventional rotary drum dryer and stationary steam dryer were supplemented by a Kumera rotary steam dryer to increase plant capacity. As a

result, Hamburg is a very interesting smelter from a drying perspective as it hosts dryers utilising three different technologies. The typical characteristics of the first Kumera steam dryer are—

- Vibratory feeder for wet concentrate
- Ø 3.75 m × 9.0 m—"standard small capacity"
- Initial capacity of 82 t/h wet concentrate at 17 bar (g) steam
- Four segments of heating elements
- Seven elements in each segment, a total of 28 heating elements
- All elements made of AISI 316L
- External heating at the wet end
- Some shorter elements at the wet end owing to flow characteristics
- Adjustable plate (at end wall) for dry concentrate removal to control retention time, drying performance and capacity
- Flexible metal hoses and manifold located inside the discharge-end housing (DEH)

The steam dryer set-up is shown in Figure 1.

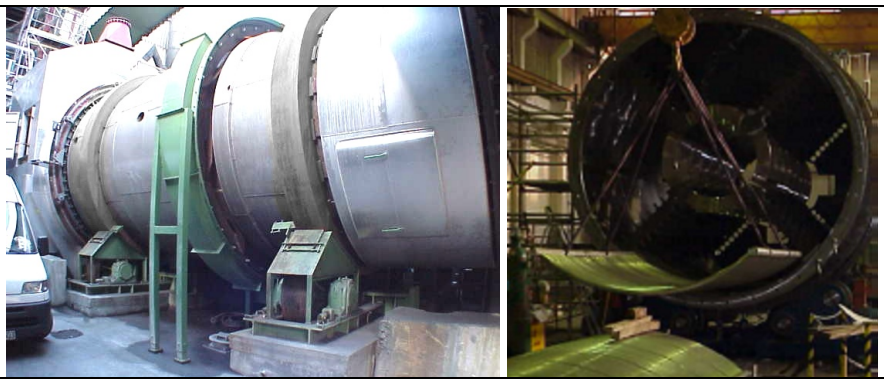

Figure 1: Kumera steam dryer in Hamburg

The heating elements were later modified by increasing them to full length; the current drying capacity exceeds 100 t/h.

Pirdop, Bulgaria, 2001

The second and third dryers were installed simultaneously in Pirdop, Bulgaria, in 2001. Each steam dryer replaced one conventional rotary drum dryer. Dryers were of equal size to the one in Hamburg. Major improvements incorporated into this dryer were—

- Slightly increased capacity of 90 t/h due to 20 bar (g) steam
- Five segments of heating elements to give better support and minimize element movement inside the dryer
- Seven elements in each segment, a total of 35 elements
- A fixed-height end-wall for dry material overflow from the dryer

The dryer set-up in Pirdop is shown in Figure 2.

Figure 2: Kumera steam dryer in Pirdop

Later on, shorter heating elements were modified to full length. A belt-type concentrate feeder was also installed when the bag-house was modified to increase the capacity of wet concentrate to 105 t/h each.

Toyo, Japan, 2003

The fourth steam dryer was installed at Sumitomo's smelter in Toyo, Japan, in 2003. The main reason for the dryer installation was a capacity increase at the smelter to supplement the existing flash dryer. This installation is notable for three reasons: it is the first non-Japanese steam dryer for copper concentrates in Japan and the first Kumera steam dryer outside Europe; also, at 160 t/h of wet concentrate, it has double the capacity of the first three dryers.

Major improvements and changes made for this dryer were—

- New dimensions of Ø 4.44 m × 10.14 m
- Double capacity of 160 t/h of wet concentrate at 20 bar (g) steam
- Nine elements in each segment, a total of 45 elements
- Standard radius elements (nine different) for future dryer family
- A change in feeder type from vibratory to belt
- Special design for drum dry-end

The set-up of the Toyo dryer together with the dry-end design and a belt feeder is shown in Figure 3.

Figure 3: Kumera steam dryer in Toyo

Vibratory feeders were supplied for the first three deliveries, all with initial capacity less than 100 t/h. Vibratory feeders were replaced, however, by belt feeders to better fit capacities greater than 100 t/h.

The gas flow rate, including both the water vapour and purging gas, were significantly increased in order to double the drying capacity. This would have resulted in higher gas velocities and possibly higher dust loads at the bag house. To prevent this, the exit opening area was increased to keep the dust load at a desired level of 150 g/Nm^3. This new design is also depicted in Figure 3, in which the end-wall of the dryer can be clearly seen.

Tamano/Hibi Kyodo, Japan, 2004

The fifth dryer was installed in Japan near Tamano city at Hibi Kyodo smelter in 2004. Here also a Kumera steam dryer was selected to match the capacity increase at the smelter. The dryer was of a smaller capacity, quite similar to the two in Pirdop. Typical characteristics of this dryer are—

- Vibratory feeder for wet concentrate
- Ø 3.75 m × 9.0 m—equal dimensions to Hamburg and Pirdop
- Initial capacity of 80 t/h wet concentrate at 20 bar (g) steam
- Five segments of heating elements
- Only 5 elements (out of a maximum 7) in each segment are utilized to match the desired capacity
- A total of 25 heating elements (maximum 35), thus allowing easy and cost-effective capacity increases in the future
- Shorter lengths of some elements
- Flexible hoses and manifold located inside the Discharge End Housing (DEH).

The set-up of the Tamano dryer is shown in Figure 4.

Figure 4: Kumera steam dryer in Hibi Kyodo

Yanggu, China, 2006

The sixth dryer, in Yanggu in 2006, was the first installation in the prime Chinese market. This was the first green field installation of a Kumera steam dryer. The Yanggu dryer is similar to the one at Toyo, with its main features being—

- A belt feeder owing to high capacity
- Ø 4.44, m x 10.14 m
- Five segments of heating elements

- Nine elements in each segment, a total of 45 heating elements
- All elements made of AISI 316L, but at full length for the first time to maximize heating-element surface area, and thus capacity
- External shell heating at the wet end for maximum capacity
- A special design for the drum dry end (see figures 3 and 5)

The dryer set-up is shown in Figure 5.

Figure 5: Kumera steam dryer in Yanggu

Jinlong, China, 2006

The seventh steam dryer was installed in Jinlong, China, in 2006. Capacity increase at Jinlong was achieved with a new 160-t/h steam dryer replacing one flash dryer. The steam dryer is of equal size and capacity as those of Yanggu and Toyo. The main improvements and changes made to this 160 t/h dryer are—

- A material outlet with a flat end-wall to give a greater heat-transfer area
- Eight elements (maximum 9) in each of the five segments to match capacity requirements
- Forty heating elements installed out of a maximum 45
- All elements made at full length
- Elements (arch pipes) in the wet end made of special duplex stainless steel to better tolerate the stress corrosion caused by the higher halide content of the concentrate
- Fabrication of the arch pipes and the main header pipes of AISI 316L

The set-up and dry end structure are shown in Figure 6.

Figure 6: Kumera steam dryer in Jinlong

A feed rate of 160 t/h of wet concentrate could be processed even though the innermost ring of heating elements was omitted to allow for a future capacity increase. This was partially carried out by a design change at the dry-end. The structure for material over-flow was changed back to a straight, flat, vertical plate with a circular hole in the middle, thus allowing a smooth and continuous flow of dry concentrate at the discharge-end housing as can be seen in Figure 6.

Guixi, China, 2006

Steam dryer number eight was installed in Guixi, China, in 2006 as a green field project. It is practically the same as the one installed in Jinlong (see Figure 7).

Figure 7: Kumera steam dryer in Guixi

Harjavalta, Finland, 2007

The main objective in Harjavalta was to replace two existing, stationary steam dryers with just one Kumera steam dryer. The dryer has an initial capacity of 136 t/h of wet concentrate. This capacity can be achieved by a standard size drum at Ø 4.44 m × 10.14 m, and only six elements instead of nine need be installed. This allows for a very simple and cost-effective capacity increase of approximately 10, 20 or 30 t/h in the future just by adding one, two or three innermost heating elements respectively. The initial structure is shown in Figure 8.

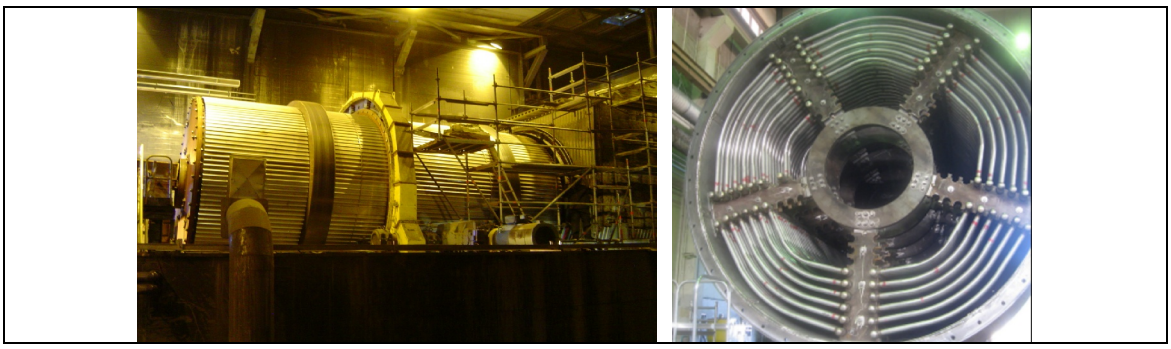

Figure 8: Kumera steam dryer in Harjavalta

The installation project in Harjavalta was very challenging because the existing dryers needed to be dismantled at the smelter site first and the new dryer installed in the very same position. In order to carry out the project in the minimum possible time, all concrete work was replaced by one complete steel frame. The entire replacement from last tap on the old plant to first tap on the upgraded plant, including removal and installation of the dryers, took only 18 days and was carried out during an annual major shut-down. Key activities during the project are shown in Figure 9.

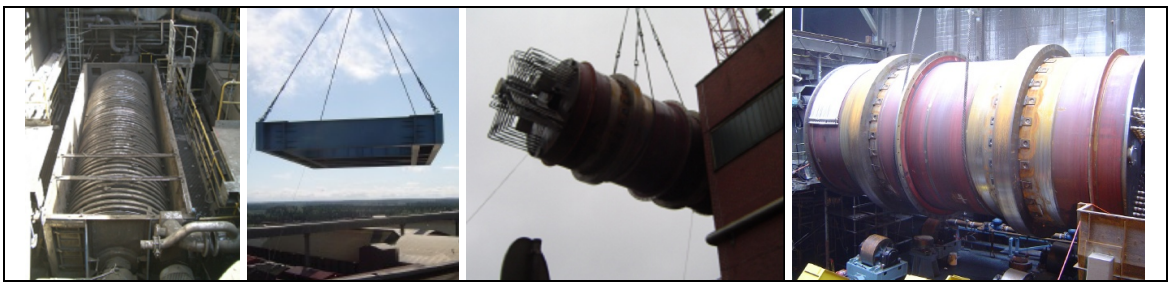

Figure 9: Kumera steam dryer installation project in Harjavalta: old dryer removal, lifting of the new steel frame and new dryer drum, and new drum installation

The initial design capacity was 136 t/h of wet concentrate. This has been increased slightly by adding one of the three omitted heating-element layers.

Onsan, Korea, 2008

Steam dryer number ten was installed in Onsan, Korea, in 2008; it replaced one existing rotary-drum dryer. With an inner diameter of 3.90 m this dryer size is unique. Special features of this dryer are listed as follows:

- A new size of Ø 3.9 m × 10.14 m, replacing the former Ø 3.75 m
- Five segments of heating elements
- Seven elements in each segment, a total of 35 heating elements

The main reason for the new size was the customer's capacity requirements. As the standard Ø 4.4 m has 9 rings of heating elements at maximum, in this instance the two outermost rings were simply removed. This results in a maximum of seven rings of elements, similar to the former Ø 3.75 by number, but all with a fixed radius equal to that of the Ø 4.4 m dryer. The dryer installation at the site and during fabrication at the Kumera Manufacturing Facilities can be seen in Figure 10.

Figure 10: Kumera steam dryer in Onsan

NEW INSTALLATIONS AND LATEST IMPROVEMENTS

Zijin, China, 2010

The most recent Kumera steam dryer (number 11) was installed in Zijin, China, as part of a green-field project. The mechanical installation was substantially completed at the end of 2010, commissioning is to take place in early 2011.

This dryer has fundamental differences over all previous dryers. The most important new features are—

- A new size at Ø 4.4 m × 12.33 m
- The highest capacity at 180 t/h of wet concentrate
- A new screw-type feeder
- All heating elements made of special duplex, high-stress, corrosion-resistant stainless steel
- A completely new design of the dry-end of the drum and discharge-end housing, which results in the relocation of flexible metal hoses and the manifold external to the system

The main objective of the new feeder type is the achievement of a tight fit with the circular inlet of the dryer. This allows much better control of oxygen partial pressure inside the dryer by preventing air ingress and enabling an inert gas such as nitrogen to be fed conveniently into the dryer through the screw-feeder inlets. The problem with belt feeders is the tendency for wet concentrate to be carried on the return side of the feeder, thereby causing a dirty environment at the discharge onto the feeder. A screw feeder avoids this problem.

A major structural improvement was carried out at the dry-end of the drum. The rotating drum does not end at the discharge-end housing, but continues all the way through it. Therefore, wearing parts such as flexible metal hoses and the manifold are now located outside the discharge-end chamber. This modification reduces wear significantly and thus has positive effects on the extent, ease, and cost of maintenance together with increased dryer availability. The set-up of the new dryer together with the new structure of the drum-end is shown in Figure 11.

Figure 11: Kumera steam dryer in Zijin with new drum-end design

Tongling, China, 2011
Steam dryers number 12 and 13 are to be installed and commissioned in Tongling, China, during 2011. This is a green-field project with a combined drying capacity of 360 t/h of wet concentrate.

The main principle of the drum extending all the way through the discharge end housing (DEH) is also utilised, but modifications to the DEH dimensions are being made in order to achieve the maximum capacity within a 12-m total length, including the drum and the discharge-end housing.

Zhuzhou, China, 2011
Steam dryer number 14 is a major milestone in rotary steam drying as it will treat lead concentrates together with lead-zinc precipitates instead of copper concentrates. The physical and chemical characteristics of this feed are quite different from those of chalcopyrite-based concentrates.

A screw feeder will be utilised because atmospheric control is crucial when treating fine sulfide concentrates and sulfur-containing precipitates which are highly inflammable.

The main new features and modifications of this dryer are summarized in the following:

- A new size at Ø 3.375 m × 11.5 m
- The dried material is primarily lead concentrate
- A completely new, patented design for the heating element configuration
- Four segments of heating elements, a maximum of 6 elements in each segment
- A screw feeder

CONCLUSIONS

This paper gives an overview of the Kumera steam-dryer reference plants, equipment modifications, and improvements.

The most significant improvements include increased capacity, better feed systems, and improved designs of the dry-material discharge and heating elements. These improvements are aimed at reducing maintenance, increasing availability, and increasing customer and end-user satisfaction.

Kumera is likely to accelerate improvements and design upgrades in the near future.

REFERENCES

1. J. Talja, S. Chen, H. Mansikkaviita, Kumera Technology for Copper Smelters, *Copper 2010, Pyrometallurgy II,* Vol.3, pp 1183–1197, Hamburg, Germany, 2010. ISBN 978-3-940276-27-8.
2. S. Chen, H. Mansikkaviita, et al., Environmental Issues in Drying Copper and Nickel Concentrates, *Sohn International Symposium*, San Diego USA, TMS, 2006, pp. 27–31.

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