NEW APPROACH TO SUGAR DRYING AND COOLING

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Introduction:

The properties of white sugar at the end of the production process have to meet requirements that are becoming more and more stringent. This is evident from the wide range of different certification systems. The process of drying and cooling the centrifuged sugar has a decisive role to play here, and this phase in the production process is increasingly developing into a conditioning phase before the sugar is stored, graded and packed. To design the required processing systems, the underlying physical conditions have to be known and adequately accounted for. Depending on the capacity of a plant, processes can be optimized in different ways.

Importance of sugar drying and cooling:

Cooling and in particular conditioning are the final steps in white and refined sugar production. This transfers the sugar into a stable condition for storage, packaging and transportation.
Depending on sugar quality, the maximum residual moisture content should be in the range of 0.03% - 0.04%, while, depending on the customer's specifications, climatic conditions and available silo technology, the maximum temperature should be between 25 and 40°C/77 and 104°F. The finished product must be free from sugar lumps.

The drying of sugar seems to follow the classic theory of the drying process but the mechanisms involved are quite different (Meadows):

- A **pseudo-constant rate stage**: the film of syrup on the surface of the crystals is under-saturated and water evaporates freely at a nearly constant rate
- A **falling rate stage**: the surface film has become sufficiently concentrated – evaporation is slowed significantly. Crystallization of sucrose begins from the supersaturated film. The higher the purity of sugar, the faster the crystallization rate.

During the important falling rate stage, two physical processes take place simultaneously:

- Water evaporation from the syrup layer
- Sugar contained in the syrup layer crystallizes

The growth of the microcrystalline layer on top of the syrup layer determines the diffusion rate of the water through this layer to the outside. A certain maximum crystallization rate cannot be exceeded. If the rate at which the crystals dry is higher than the rate at which the sugar contained in the solution can crystallize, amorphous sugar will form, which can reduce the diffusion of water significantly. The result is sugar with high residual moisture content.

Experience shows that freshly dried and cooled crystal sugar undergoes a conditioning phase during the first few days after production. Depending on ambient conditions, freshly produced sugar can lose its water-binding properties again within a relatively short time (within the first one to two days), i.e., it releases part of the bound water. In silos or in the packed sugar this released water can cause lumps and caking. Our experience clearly shows that slow drying combined with gentle movement has a positive effect on the storage properties of sugar.

Well-established Solutions:

After gaining practical experience with various drying systems, the equipment as well as the whole concept of sugar drying and cooling have been further developed continuously.

Sugar drying always takes place in a drum dryer. Gentle movement in between the crystals prevents the formation of amorphous crystal layers on the crystal surface and the countercurrent principle makes the process easy and effective. Furthermore, it allows for a limited cooling effect. It might therefore be possible to omit an additional cooler in the case of smaller capacities.

Fig. 1: Installation of a rotary dryer/cooler Ø 2.6 x 9 m

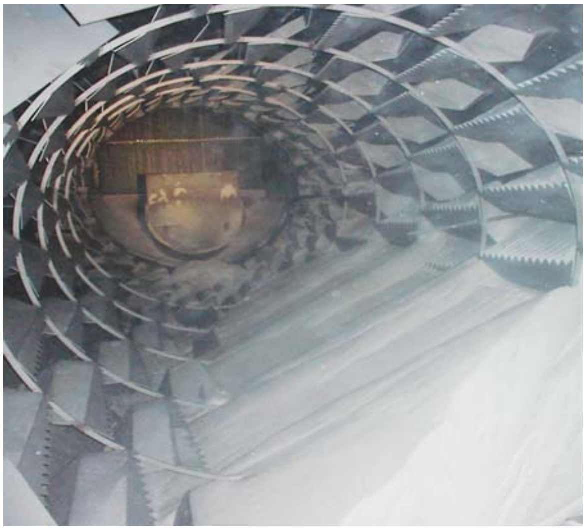

Fig. 2: Sugar distribution in a drum at standstill

Cooling of rather small capacities may be intensified by means of an air conditioning system (chiller).

As soon as high cooling demands are required for higher capacities, a separate sugar cooler should be considered. In a continuous process, BMA developed the fluidized bed apparatus with integrated heat-transfer surfaces (Fig. 3). Compared to a conventional fluidized bed cooler, this technology is designed in a more compact way and needs significantly less space.

Advantages of the fluidized bed technology:

- Excellent heat transfer characteristics due to disaggregation of crystals and therefore increased crystal surface
- Gentle sugar treatment thanks to disaggregation means less friction favorable side effect: less dust
- Additional drying capabilities enable lower thermal stress in drying drum

When additionally equipped with an air conditioning system, the unit can be used without any reservations under extreme incoming air conditions and in tropical climates

Fig. 3: Horizontal fluidized bed cooler with integrated cooling blocks

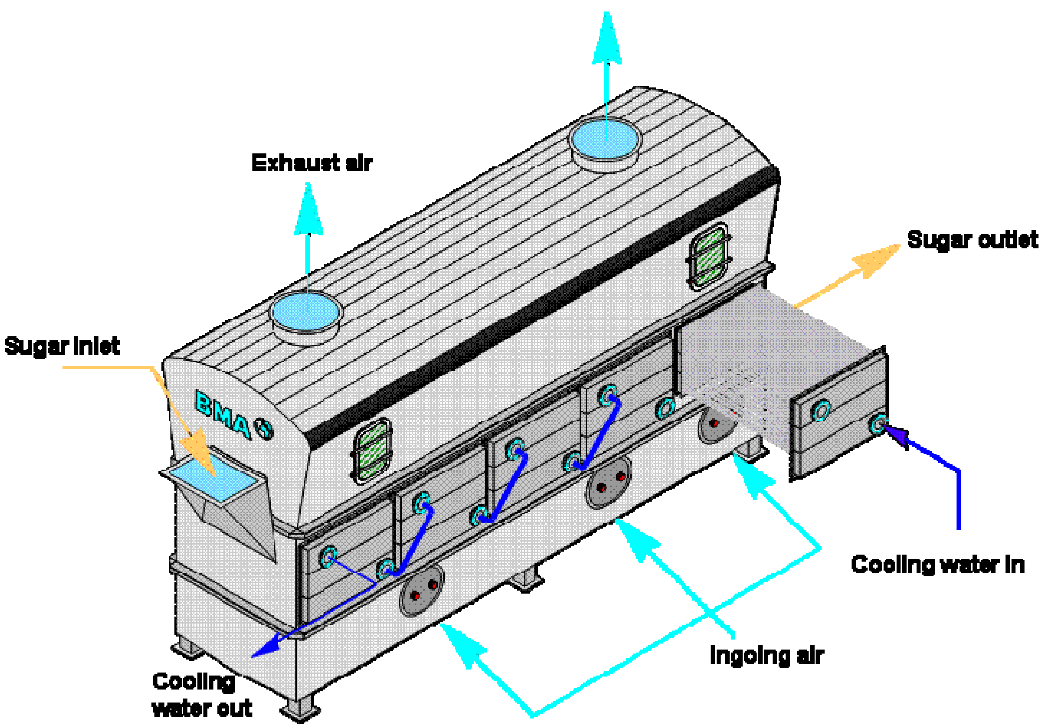

Fig. 4: Fluidized bed unit with integrated heat transfer surfaces - diagram

Advantages of the integrated cooling blocks
- significantly improved efficiency of cooler
- considerably reduced air consumption
- resulting in smaller size of whole unit

New vertical fluidized bed conditioner (VFC):

BMA faced the following challenges:

- Expansion: (a) factories are aiming for higher capacities but have only limited space; (b) Horizontal fluidized bed conditioner: 4-12m length, 1.5-3.5m width
- Energy savings: (a) high energy costs; (b) environmental issues and the resulting legal requirements;
- Sugar quality: (a) storage; (b) transportation
- Climatic conditions: (a) high humidity of ambient air (b) high temperatures of ambient air

Figure 5 shows the design of the sugar conditioning unit. By opening and closing the air distribution plate, the product is transported from the process area into the lower area of the unit, where it is discharged by a rotary air lock. The solid matter flow is controlled by periodical opening and closing of the distribution plate. This allows a uniform residence time of the product.

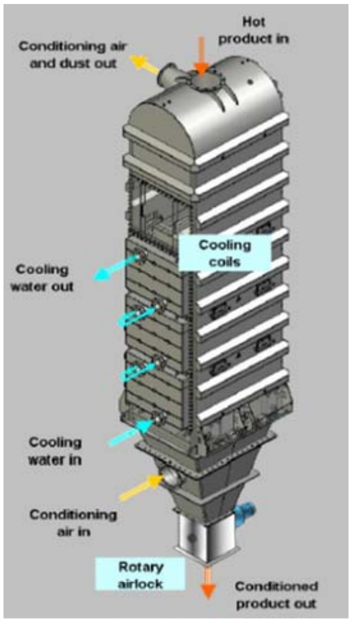

Fig.: 5: Design of vertical fluid-bed sugar conditioner

Owing to the large free surface of the distribution plate, the pressure drop is very low. The sugar quantity inside the apparatus is controlled via the pressure drop across the fluidized bed. Figure 6 is a schematic diagram of this equipment.

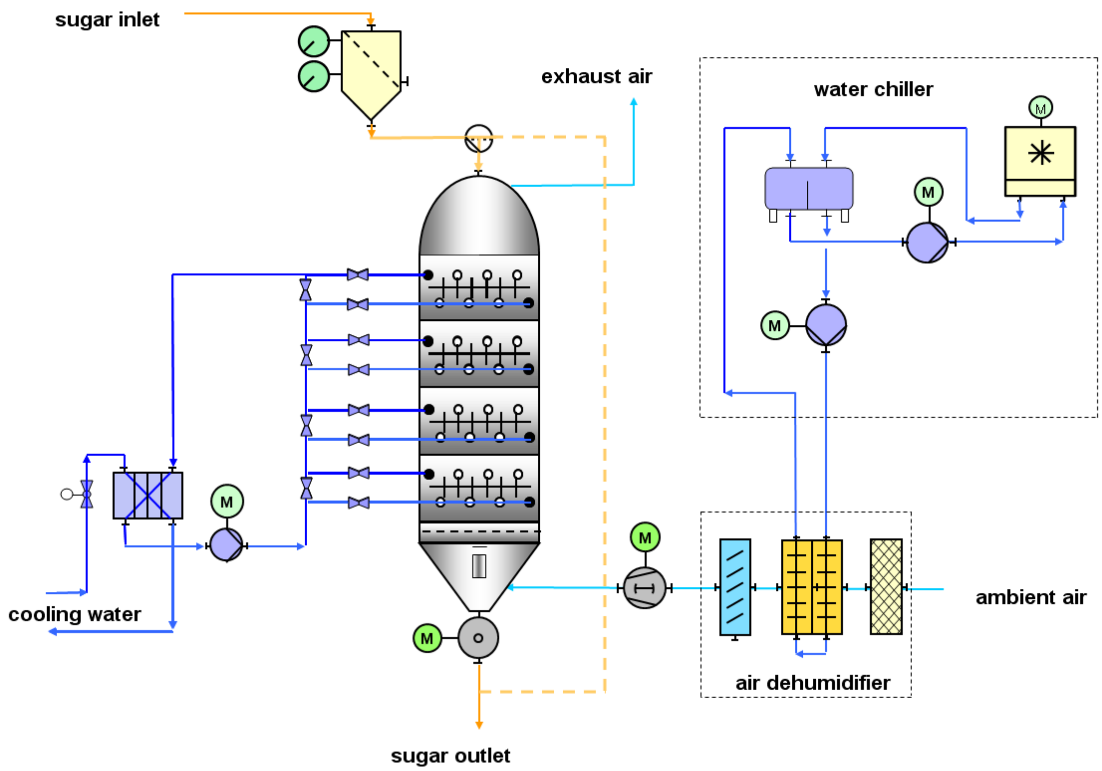

Fig.: 6: Schematic diagram of a vertical fluidized-bed conditioner

BMA's aim in developing the vertical fluidized bed conditioner VFC was to offer the sugar industry a suitable alternative to the horizontal fluidized bed with a compact build and reduced air consumption, while keeping the advantages of a fluidized bed compared to an airless moving column system.

The vertical fluidized bed conditioner combines the advantages of a horizontal fluidized bed cooler and an airless moving column system.

VFC Series	
■ ***Width***	***2000 mm / 78.7"***
■ ***Length***	***1800 mm / 70.9"***
	Total height
■ ***VFC 16/2***	***5360 mm / 211.1"***
■ ***VFC 16/3***	***6320 mm / 248.8"***
■ ***VFC 16/4***	***7280 mm / 286.6"***
■ ***VFC 16/5***	***8240 mm / 324.4"***

Fig. 7: Dimensions of the BMA VFC series

Due to the fluidization, vertical fluidized bed coolers have a three to four times higher heat transfer rate than the airless moving column system (Fig. 8), although they have equally compact dimensions.

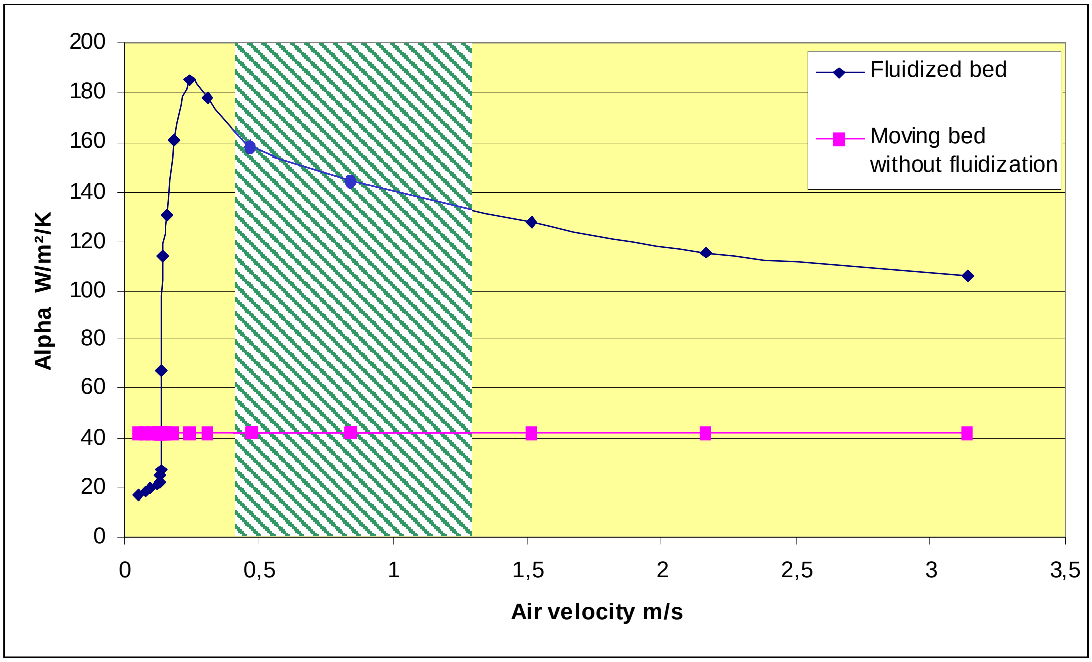

Fig. 8: Heat Transfer Rate in Vertical Coolers

This sugar conditioner with a vertical fluidized bed design and installed cooling pipes has a number of advantages which can be described as follows:

- Excellent heat transfer with the fluidized bed principle
- Heat exchangers arranged on top of each other, resulting in a small cross section and low air requirements (reductions of 50 to 80% compared to the horizontal fluidized bed version are possible)
- Outgoing air passes small filters for dust separation and is transferred to existing aspiration systems or put to further use in existing drum dryers/coolers
- In view of the small air rates, the ingoing air can be dehumidified efficiently; perfect solution under tropical air conditions
- Controlled temperature of heat carrier medium for constant sugar outlet temperatures
- Maximum utilization of the air and the heat carrier medium with consistent use of the counter-current principle
- Product flow (from top to bottom) not forced by air flow but by gravity
- Openings in air distribution bottom maintain product flow also in the absence of air flow (emergency operation)
- Only a small air volume is required to maintain the fluidized bed (no transport function)
- Mass transfer (drying) can take place

Conclusions:

Over several years, BMA continually improved the sugar drying and cooling process as well as the equipment. Development has always focused on the optimization of sugar quality in terms of residual moisture, taking different climatic conditions into account. After launching the fluidized bed coolers, the supplement of water-cooled heat transfer units to the product compartment formed the next important stage of development. Unit size and the demand for process air were reduced significantly. Now, by changing from horizontal to vertical design BMA has again reduced the equipment's footprint and the process air quantity.

The new Vertical Fluidized bed Conditioner meets the most stringent drying and cooling demands. It can be used in new factories as well as to increase production in existing facilities, thanks to its compact design. Furthermore, it presents a standalone solution between curing and loading.

References:

Meadows, D.M. (1997), Sugar drying, conditioning & storage – an overview; Pak. Sugar Journal Oct.-Dec. 1997