A NEW APPARATUS FOR DRYING AND COOLING OF CRYSTAL SUGAR OPERATING BY THE FLUIDIZED-BED PRINCIPLE

\- NOT FOR PUBLICATION -

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1. INTRODUCTION

In recent years, scientific investigation and industrial application of the fluidized-bed technology has been making great progress. This can be attributed, in the first place, to the intensified process research work that was made possible by the solids fluidization technology.

In a fluidized solids medium, for example, heat, mass and pulse transfer proceeds faster by 1 magnitude than in a bulk medium (1,2).

As drying and cooling of crystal sugar is a process whose intensity largely depends on the mass and heat transfer, theoretical considerations can disclose a number of advantages that are associated with the use of the fluidized-bed technique instead of the conventional rotating drum technology.

Though the parameters specified for the individual dryers are usually better than comparable solutions using the rotary dryer principle, a comparison with one another reveals some variations. Nowadays, heat and mass transfers can be calculated beforehand so as to adapt a fluidized-bed crystal sugar dryer in an optimum manner to given conditions in respect of inlet and outlet moisture and of inlet and outlet temperatures in order to achieve the maximum economic efficiency.

This allows the fundamental behaviour of sugar in drying and cooling to be computed by means of a physically founded mathematical model using experimentally determined parameters.

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The fluidized-bed dryer/cooler described here was developed specifically for use in the sugar industry, but can be employed for similar crystalline products as well (3). This dryer/cooler operates by the temperature-swing principle.

2. PRINCIPLE OF OPERATION

The crystal sugar drying and cooling plant is composed of the following essential units as described in this picture - Fig. 1 -, from which the principle of operation can be seen as well.

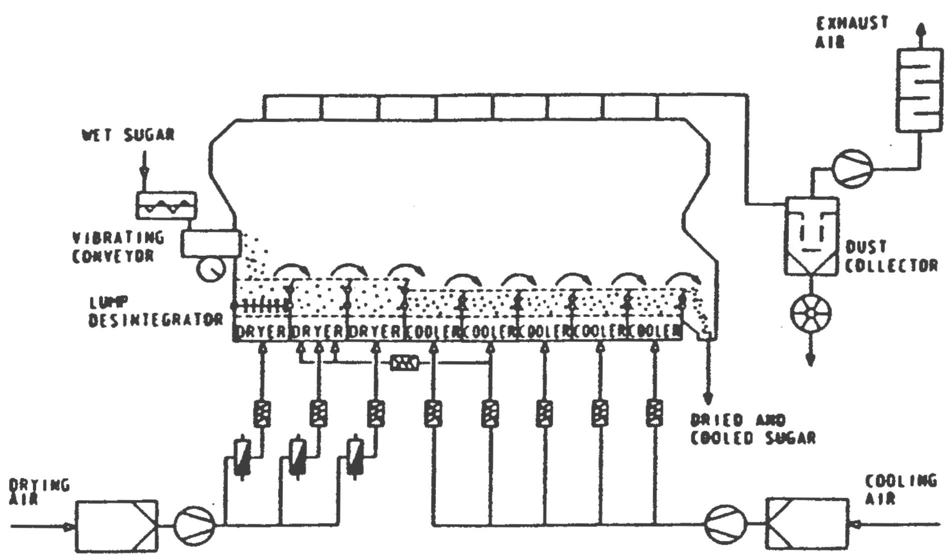

Fig.1: CONFIGURATION OF FLUIDIZED-BED SUGAR DRYER AND COOLER SYSTEM

The schematic illustrates that the fluidized-bed dryer/cooler has a total of eight zones.

Between all zones a weir is provided, which is adjustable in height.

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At the downstream end of zone 8 a vertically adjustable outlet weir is provided.

Separate fans serve for feeding the drying and cooling air to the individual zones.

The type of screen used for this dryer can be seen from the next picture - Fig. 2 -. Its duty is to pass on the fluid medium as evenly and finely distributed as possible to the solid material, without the solids trickling through the porous distributor plate and clogging it if there is no gas pressure under the plate.

Due to the fact that the fluidizing conditions provide for very intensive heat and mass transfer, a large portion of the water adhering to the sugar is removed as early as in the first zone.

Fig. 2 : "CONIDUR" DISTRIBUTION PLATE

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In the centre of this first zone there is a paddle unit - Fig. 3 - which disintegrates any sugar lumps that may have formed en route. This disintegrating effect is enhanced by the slope of the distributor plate of zone 1 towards the centre.

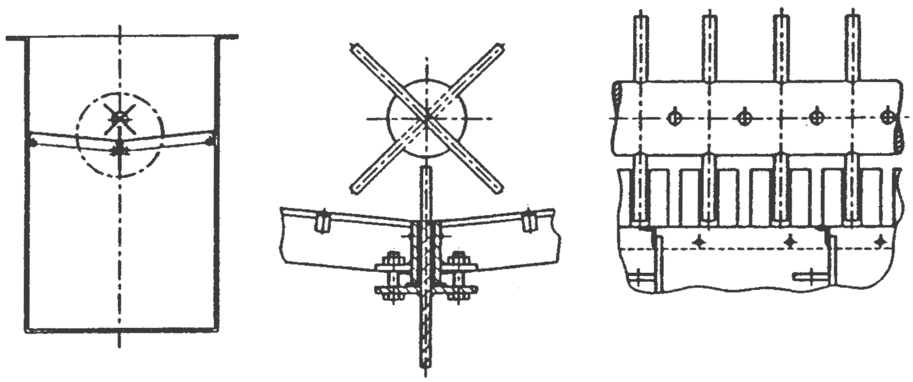

Fig.3: PADDLE-TYPE LUMP DISINTEGRATOR

As the sugar/air equilibrium temperature is already reached after just a short travel through the fluidized bed, the bed level is reduced to save electric energy for the cooling air-fan.

Hot air with a temperature of approx. 100 °C enters zone 1 subject to the relative apertures of the zone segments. Zone 2 receives both hot and cold air and therefore has a special duty which is called temperature swing - Fig. 4 -.

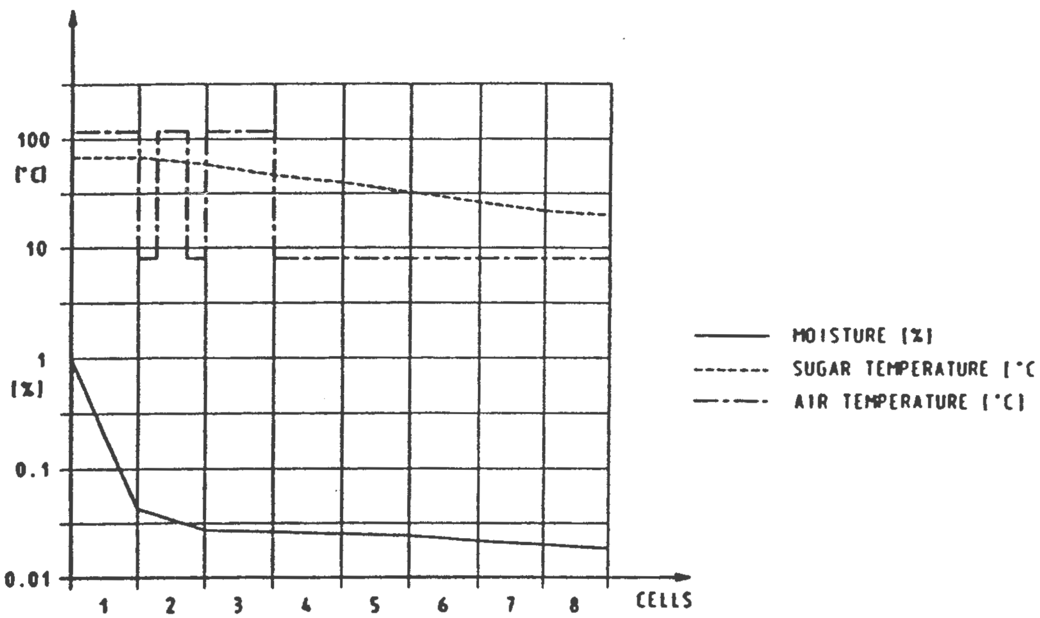

Fig.4: TEMPERATURE-SWING WITHIN THE DRYING ZONE OF THE DRYER

This temperature swing further intensifies the drying process along with low energy requirements. The temperature swing is produced as follows: under the distributor plate ducts are provided at right angles to the direction of sugar flow, through which cold and hot air is aspirated alternately.

The specific configuration, and in particular the swing, prevents the sugar from being heated to too high a degree, without having to accept high losses of propulsive force caused by too low an ingoing air temperature.

Sugar moisture and temperature in relation to the process air within zone 1 to 8 can also be seen from the diagram - Fig. 4 -.

The gentle sugar drying and cooling process in the fluidized bed brings about an excellent product quality, in particular in regard to the brightness of the crystals and the dust exiting the unit.

The fluidizing chamber flares out above the fluidizing bed, - Fig. 5 - which results in a reduced air velocity, and this enables sugar particles that were expelled from the bed to drop back again more easily.

It is therefore necessary that the expansion chamber be designed for an appropriate height.

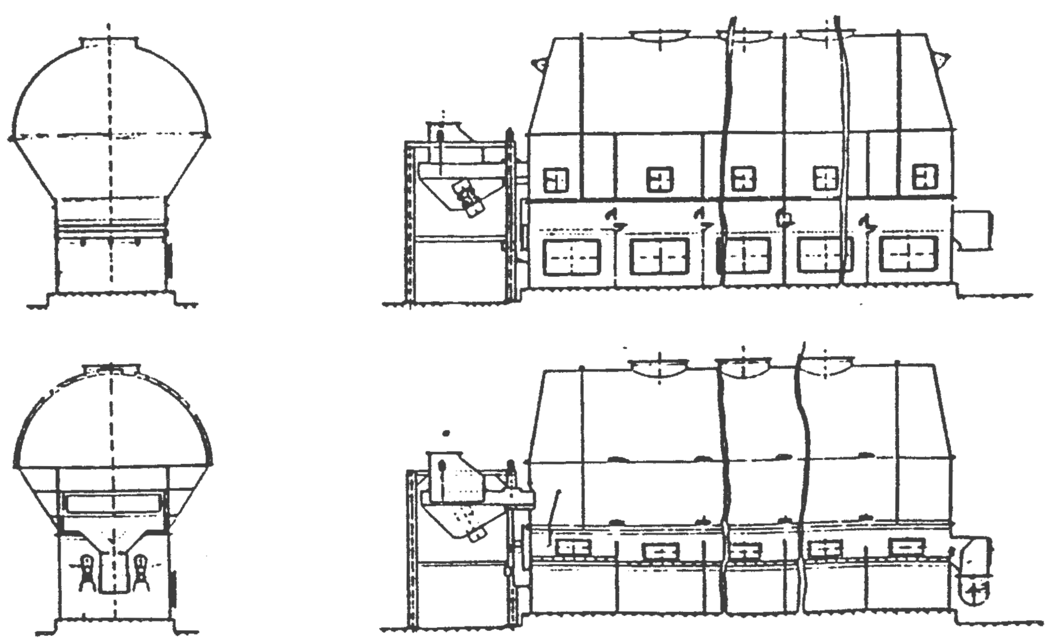

Fig.5: SIDE VIEW OF DRYER/COOLER

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The enlarged cross-sectional area above the fluidized bed allows the dust discharge from the dried material to be reduced to appr. of 0,5 % related to sugar throughput.

3. Design parameters

The next table - Fig. 6 - shows some typical data of a fluidized-bed dryer/cooler:

. Moisture of sugar - in	up to 1.5%
. Temperature of sugar - in	appr. 60 °C
. Residual moisture of cooled sugar	0.025%
. Temperature of cooled sugar	8 - 10 K above cooling-air inlet temperature
. Steam and power consumption per ton of sugar throughput:	
steam	20.0 kg/t (40 lbs/sht)
electric power required	4.0 kWh/t (3.6 kWh/sht)
. Retention time	10 min.
. Required screen area	0,5 m² per t of sugar (4.9 sq.ft/sht)
. Pressure loss:	
of dryer	3.500 Pa
of distribution plate	1.000 Pa
. Air quantity	2.500 Nm³/t (80.260 cu.ft/sht)
. Air velocity	1,1 - 1,3 m/s. (3.6-4.3 ft/s)
. Bed height	400/300 mm (appr. 12-16 inch)

The plants are standardized in 14 sizes for throughputs ranging from 3 to a maximum of 75 t/h (82.5 sht/h).

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The temperature difference sugar outlet - air inlet is therefore only 4 - 6.5 K on an average.

The specific electric consumption is 0.89 kWh/t (0.8 kWh/sht) of sugar throughput, measured without pressure loss in heat exchangers, air filters, ducts and dust separation.

The dust content reached max. 0.25 % of the sugar throughput.

5. COMPARISON

A Comparison of the essential parameters, at the same throughput, of the widely used rotary dryer/cooler vs. the fluidized-bed dryer/cooler can be seen from the following table - Fig. 9 -:

	Fluidized bed	Rotary
Residual moisture	less than 0.025 %	0.03 %
Temperature-out	T = 8 - 10 K	T = 15 K
Floor space requd (for 20 t/h unit)	22 m² (237 sq.ft)	75 m² (807 sq.ft)
Height (for 20 t/h unit)	6.30 m (20.67 ft)	5.50 m (18.08 ft)
Dust percentage	less than 0.5 %	less than 2 %
Brightness	brighter than rotary dryer	not so bright as fluidized bed dryer
Total energy consumption of plant - electric - steam	 4.0 kWh/t (3.6 kWh/sht) 20.0 kg/t (40 lbs/sht)	 3.1 kWh/t (2.8 kWh/sht) 23 kg/t (46 lbs/sht)
Dryer weight (for 25 t/h unit)	36 t (39.7 sht)	77.5 t (85.5 sht)
Price	58 %	100 %

6. SUMMARY

The model as presented allows to determine the sugar temperature and sugar moisture profiles over the length of the dryer. Drying and cooling proceed successively in a drying zone, a temperature-swing zone and a cooling zone.

This configuration, and especially that of the temperature swing, prevents the sugar from being heated to too high a degree, without having to put up with substantial losses of propulsive force due to too low a temperature of the ingoing air.

Consequently, the newly developed dryer/cooler represents a solution which, as compared with the drum drying technology, means substantially less use of mechanical equipment along with equivalent and partly even better energy parameters, and which due to the gentle treatment of the crystals in the fluidized bed produces sugar of a higher quality.

The following features and advantages were verified both in small-scale experimental plants and in large-scale industrial plants designed for a sugar throughput of 20,000 kg/h (44,000 lbs/h) and 70,000 kg/h (154,000 lbs/h).

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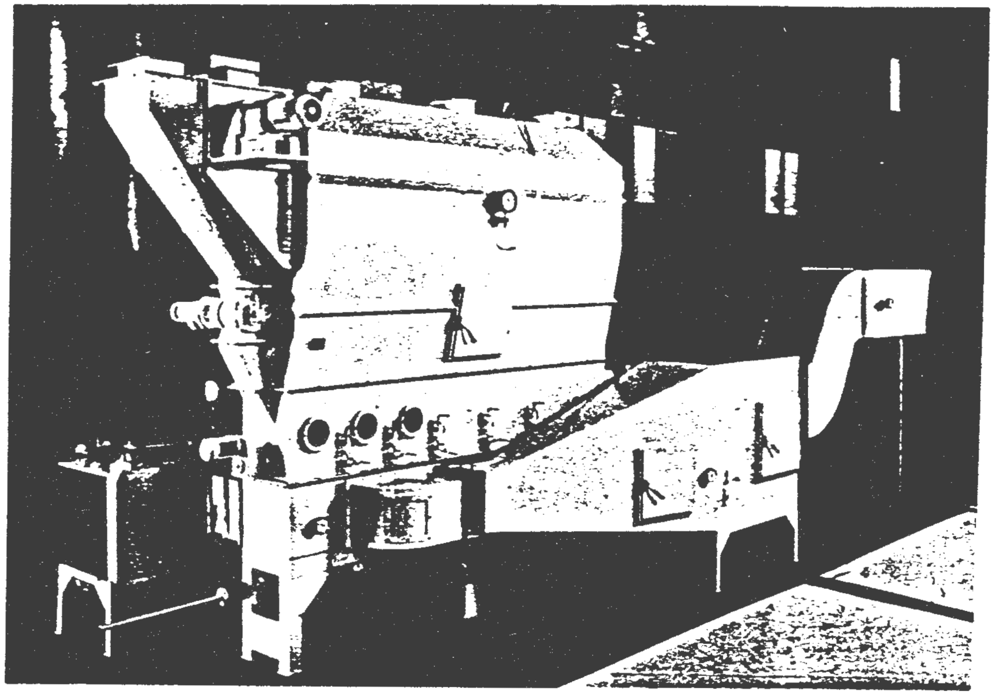
The characteristics of the described dryer-cooler - Fig. 10 - can be summarized as follows:



. Drying and cooling in one single unit.

. No moving parts inside the dryer - except for the paddle unit.

. Uniform sugar drying thanks to the purpose-made perforated blow deck; optimum drying and cooling air profiles; paddle unit serving as a lump and tailings disintegrator.

. Intensified mass transfer by temperature swing (warm and cold air acting alternately on the sugar in a specific section of the dryer/cooler).

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. Gentle treatment of crystals, as they are supported by the fluidizing air only, therefore sugar crystals largely retaining their brightness.

. Low air flow rate through the blow deck and gentle treatment of crystals, minimizing the amount of dust to be removed.

. Low sugar outlet temperature along with low cooling air requirements owing to optimum heat exchange between cooling air and sugar crystals.

. Insusceptibility to fluctuations in sugar feed, sugar inlet temperature and moisture.

. Comparatively small floor space.

. Minimized servicing and maintenance requirements.

. Low initial cost.

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