RAW SUGAR DRYING USING A FLUIDIZED BED SYSTEM AT SEZELA

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Abstract

A practical discussion about the operation of the drier and the effects of different operating conditions on final sugar quality is presented.

Introduction

As part of the mill expansion programme Sezela installed two 40 ton per hour fluidized bed drier/coolers to handle its raw sugar production at a cane crush rate of 500 tons per hour. Fluidized bed driers were chosen in preference to the more conventional rotary louvre type for a number of reasons, amongst which were capital cost (about 60% of that of a rotary drier at the time of order), mechanical maintenance considerations, and size and overall weight, which makes it possible to locate the plant on first or second floor level as no heavy foundations are required.

The driers were commissioned at the beginning of the 1982/83 season and have proved to be reliable, simple to operate, and capable of handling even very badly cured sugar.

A number of process protection devices are provided on the plant. These include complete plant trip-outs for, amongst others, low air flow, low heating zone temperature, and high sugar bed height. Each of these is there for a good reason but it was soon discovered that, if set too critically in terms of sugar quality, frequent unnecessary plant shut-downs were caused. It was with this in mind that a comprehensive performance evaluation of the plant was undertaken.

Description of Plant

The plant consists basically of a vertical cylinder 3,6 m in diameter, and 8,0 m high, divided into an upper and lower compartment by a perforated plate. These compartments are further sub-divided by means of vertical baffles[2] to give separate drying and cooling zones, and in the cooling zone above the perforated plate is a further vertical baffle which is arranged to give an approach to plug sugar flow.

Air is supplied by a forced draught fan driven by a 200 kW motor. The air duct after the fan splits into two, one containing a steam/air heat exchanger which provides hot air to the underside of the perforated plate in the drying zone, and the other providing ambient air to the underside of the perforated plate in the cooling zone.

Wet sugar is introducted into the drying zone above the perforated plate and distributed evenly over the zone by means of a feed paddle driven by a 3 kW motor sited immediately below the feed point. Passage of air through distribution jets in the perforated plate fluidizes the sugar, forming a bed of controllable depth. Flow of sugar from the drying to the cooling sections is controlled by an adjustable gate in the separating baffle, and flow out of the cooling section by a variable speed choke-fed vibratory feeder.

Having passed through the sugar bed, air from the two zones combines in the upper section of the drier and is extracted by a Roto-clone, i e, a combination exhauster and dust collector, before being exhausted to atmosphere. The Roto-clone is powered by a 90 kW motor.

A general layout is shown in Figures 1 and 2.

The effect of process variables on performance

The object of the exercise was to evaluate the effects of the fluidizing air velocity, bed temperature, and bed depth on final sugar moisture and temperature, and at the same time to measure sugar residence times. Air velocity was calculated from the fan performance curve and sugar moisture was determined by oven-drying.[3]

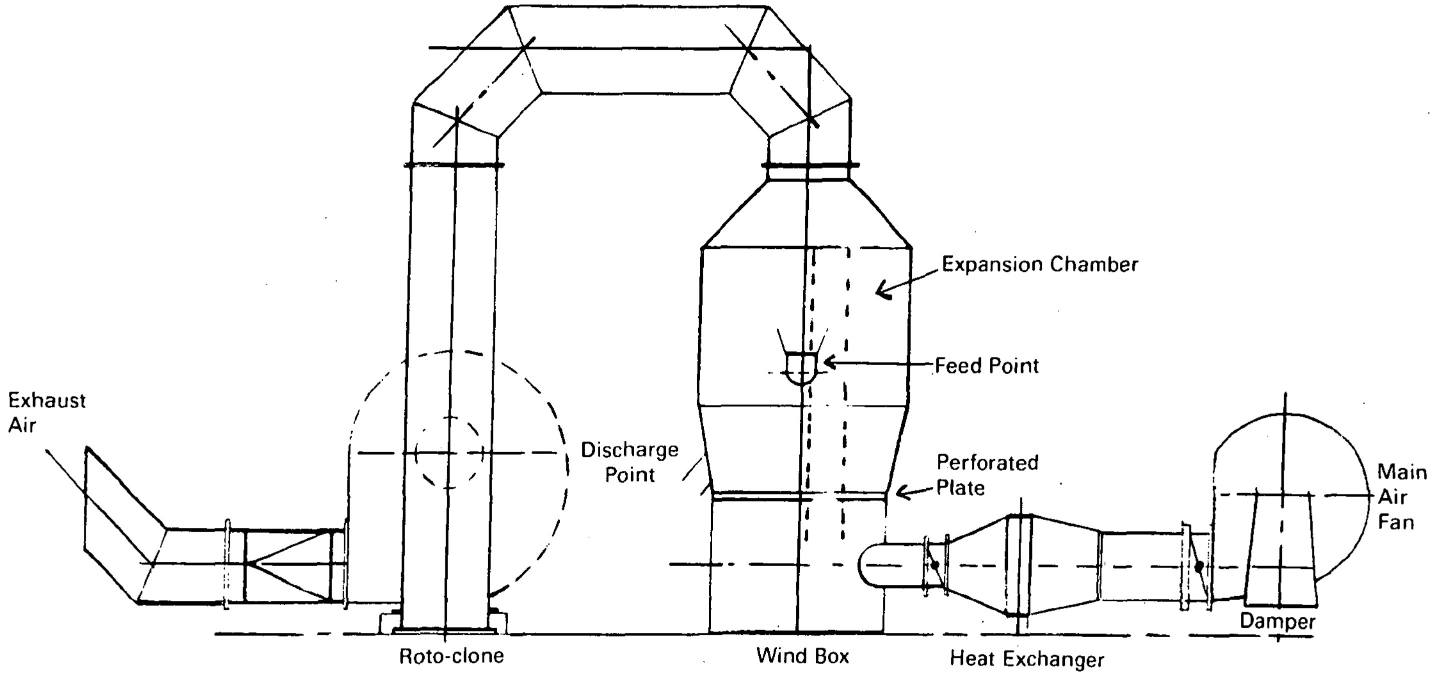

FIGURE 1

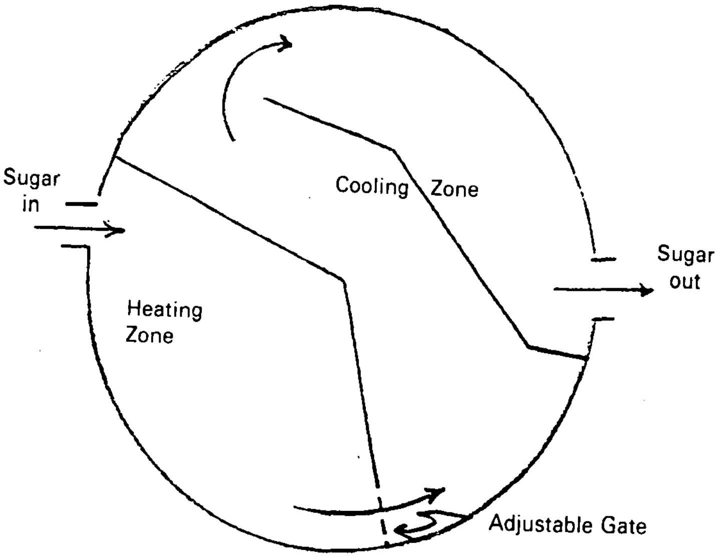

FIGURE 2 Plan view of baffle arrangement

Because of the constraints of maintaining production under difficult conditions at Sezela the experimental approach used was kept very simple.

The method of testing was to hold the variable under investigation constant and then to go through the range of the other two variables which required twenty seven runs. The results have been averaged for each of the variables held constant and are presented, together with the confidence intervals, in tables 1 and 2.

TABLE 1

Resultant sugar moistures at various operating conditions

Air Velocity	1,0* ms^{-1}		1,2* ms^{-1}		1,4* ms^{-1}	
		5% confidence interval		5% confidence interval		5% confidence interval
Moisture	0,122	±0,015	0,129	±0,032	0,147	±0,046
Drying Zone Sugar Temp.	40°C		45°C		50°C	
		5% confidence interval		5% confidence interval		5% confidence interval
Moisture	0,157	±0,019	0,124	±0,015	0,118	±0,024
Bed Pressure Differential	2,0 kPa		2,25 kPa		2,5 kPa	
		5% confidence interval		5% confidence interval		5% confidence interval
Moisture	0,150	±0,051	0,112	±0,018	0,136	±0,016

Average inlet condition: Tons sugar per hour 35
Sugar moisture 0,38%

* The absolute value of the air flow proved difficult to measure. It must be stressed that these values are only approximations

Air flow

Air flow has critical low and high points, the low point being that at which the sugar bed de-fluidizes, and the high at which the upward force of the fluidizing air exceeds the downward force of the sugar granules by virtue of their weight. The Sezela drier was designed for a fluidizing air velocity of 1,45 ms^{-1}, but at this velocity excessive dust carry-over into the Roto-clone was experienced, and as the consequent dust emission from the unit was deemed unacceptable for practical purposes 1,45 ms^{-1} was stipulated as being the maximum operating air velocity. The sugar bed remains "fluid" at air flows as low as about 0,85 ms^{-1}, but it is not really practical to run at this level as the resilience of the drier in handling intermittent surges of wet sugar is considerably reduced, as is the performance of the cooling section, which relies on a large volume of air for efficient operation.

There is no statistical evidence of any relationship between final sugar moisture and airflow, but it is suspected that at high air velocities channelling through the sugar bed occurs, decreasing the intimacy of sugar crystals and air, but this is not certain.

As a result of the findings it is considered that air flow should be restricted to a "safe" fluidizing velocity, (under normal circumstances) any excess velocity tending only to aggravate the problem of dust handling. It is recognised, however, that high velocities came into their own when having to deal with poorly cured sugar which fluidizes rather reluctantly.

Sugar Bed Temperature

Unfortunately limitations in air heating capacity prevented further tests at temperatures above 50°C.

It can be seen from Table 1 that there is an inverse relationship between final sugar moisture and drying zone sugar temperature. This trend was not unexpected, even though it differs somewhat from the findings of FitzGerald et al.[2] What is interesting is that even at 40°C, the average sugar moisture is almost within the VHP specification, (Table 1) and that with incoming sugar temperatures of 40–45°C very little (if any) heating of the fluidizing air is necessary — something which is useful in the event of heat exchanger failure — but it is important to watch sugar inlet temperatures carefully, and do as much drying in the centrifugals as possible when running under these conditions.

Bed Differential Pressure

Bed differential pressure is the pressure difference between the bottom and the top of the sugar bed. It is proportional to bed depth (which cannot be measured directly) and bears a linear relationship with sugar residence times. (See Fig. 4).

The effect of bed differential pressure on final sugar moisture is shown in Table 1. The results indicate that there could be a statistically significant difference in average moisture in the runs at 2,25 kPa and 2,5 kPa. These results are not different from those of FitzGerald et al.[2] It is, however, difficult to draw any firm conclusion from the results other than to start theorizing once again about channelling, or perhaps that at the residence times under consideration only the moisture on the surface of the sugar crystals is removed and considerably longer residence times are required to gain access to moisture within the crystals.

Final Sugar Temperature

From Table 2 it may be concluded that there is an inverse relationship between fluidizing air velocity and final sugar temperature, and a direct relationship between drying zone sugar temperature and final sugar temperature, while bed depth displays no trends.

Sugar Residence Times

Although no problems were anticipated with sugar flow characteristics in the drier, residence time tests formed part of the overall plant evaluation exercise.

The method employed in doing these tests was rather crude but nevertheless effective. It consisted of introducing a plug of a coloured sample of wet sugar being dried at the time to the inlet of the drier and then sampling the dried sugar at 2 minute intervals. The tracer response was obtained by counting the

TABLE 2

Resultant sugar temperatures at various operating conditions

Air Velocity	1,0 ms^{-1}		1,2 ms^{-1}		1,4 ms^{-1}	
		5% confidence interval		5% confidence interval		5% confidence interval
Temp. (°C)	45.0	± 1,54	43,8	± 2,17	40,4	± 1,93
Drying Zone Sugar Temp.	40°C		45°C		50°C	
		5% confidence interval		5% confidence interval		5% confidence interval
Temp. (°C)	40,6	± 1,89	43,1	± 1,70	46,4	± 2,09
Bed Δ P (kPa)	2,0 kPa		2,25 kPa		2,5 kPa	
		5% confidence interval		5% confidence interval		5% confidence interval
Temp. (°C)	42,7	± 2,43	42,9	± 2,51	44,1	± 2,68

Average inlet condition: Tons sugar per hour 35
Inlet sugar temp. 43°C
Ambient air temp. 26°C

number of coloured crystals in a 60g sub-sample of the drier sugar samples.

The tests were repeated over a range of bed differential pressures the results of which are displayed graphically in Figures 3 and 4.

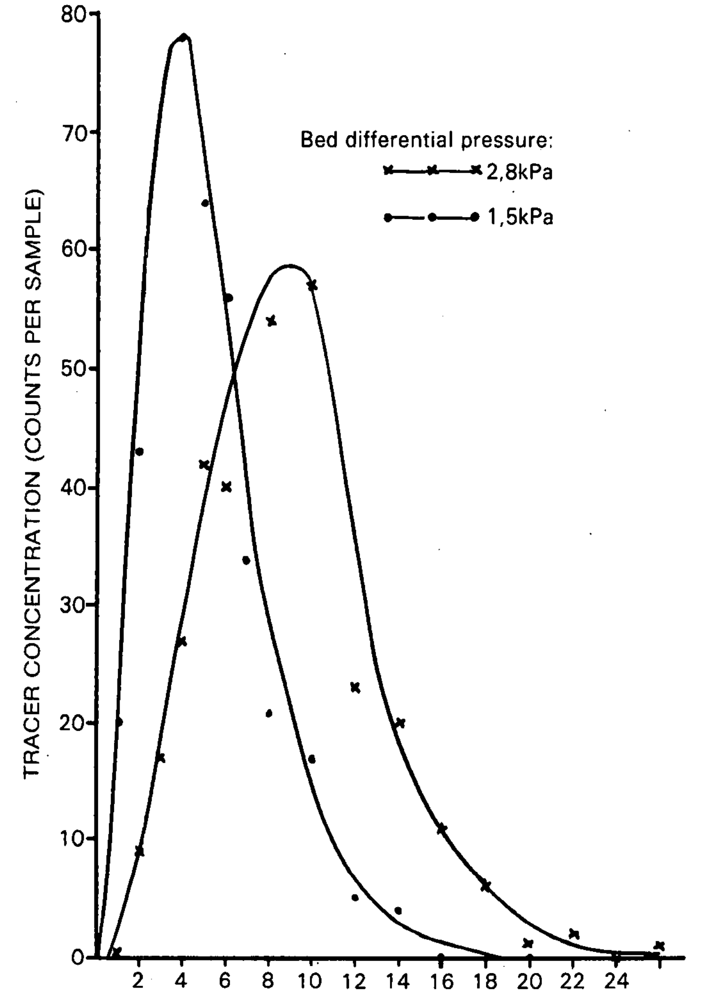

FIGURE 3 Residence time distribution and a function of bed differential pressure

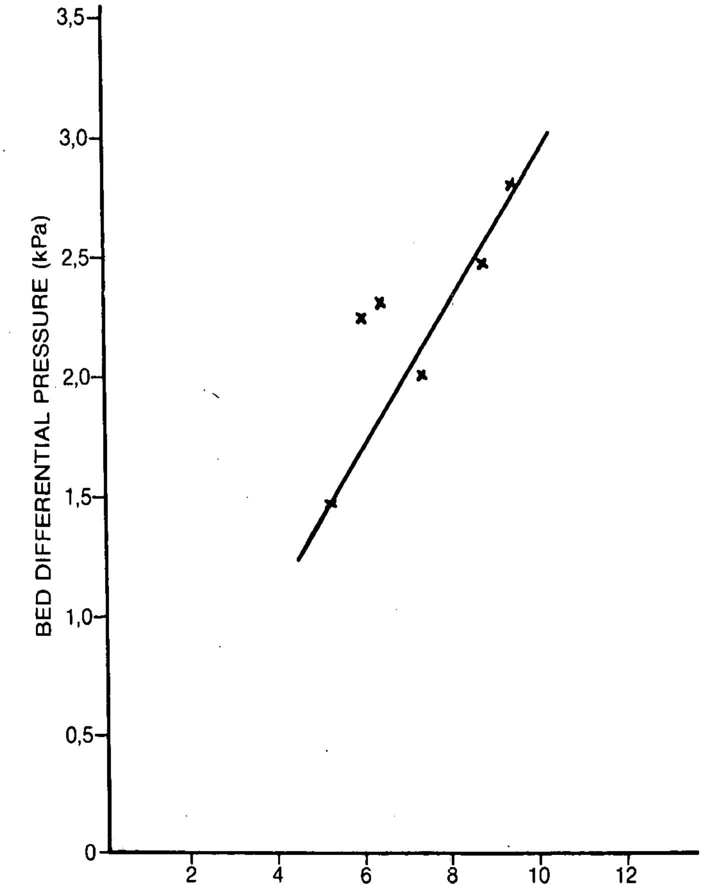

FIGURE 4 Mean Residence time as a function of bed differential pressure

Drier Operation

Operating the drier is very simple. Starting the plant involves switching on the various components of the drier, adjusting the Roto-clone water flow, the air flow, and then setting the desired bed differential pressure. From then on the plant looks after itself, the sugar discharge rate varying with the feed rate so as to maintain the correct bed height. Should any problem occur the plant shuts itself down, sounds an alarm and the problem area is illuminated on an annunciator panel. Shut-down is equally simple and involves over-riding the bed height controller to enable the drier to empty itself out, and then simply switching everything off.

Routine maintenance consists almost entirely of removing caked sugar from the inside of the drier (normally only a little around the inlet) and checking that the numerous pressure probes are clear. The inlet air filters require cleaning fortnightly. On the mechanical side there is nothing more to do than check V-belt tensions and grease bearings.

The drying station however, is not entirely without problems. Dust collection was the first problem and was felt in two areas. The first was in the scrubbing of the dust-laden exhaust air itself, the Roto-clones not being able to arrest the very fine dust particles, about 5% of which are below 0,2 micron in size.[1] The second was in the separation of large amounts of bagacillo from the sugar. This finds its way into the scrubbing water and with recirculation soon accumulates until it starts blocking filters in the water line prior to the spray nozzles.

Eliminating dust emission from the Roto-clones remains a problem but it cannot really be said to be the fault of the drier. To overcome the bagacillo problem a once-through — as opposed to a continual bleed-off — system of scrubbing water was adopted. While this solved one problem it created another

— that of preventing the growth of slime in the Roto-clone ducting as the cost of continual dosing of a biocide on this once-through system became prohibitive. The drier is stopped and the Roto-clone steamed out every 24 hours. In summary, at a sugar production rate of 35 tons per hour approximately 6,5 tons of sweet water at about 4° brix containing 5,5 kg of bagacillo are returned to mixed juice every hour.

The possibility of dust generation by abrasion or attrition of sugar crystals in the drier has been considered and a number of grain size determinations have been done on sugar before and after the drier. The results shown in Table 3 indicate that there is general improvement in the crystal size of sugar after drying. All the tests were done at "normal" operating conditions.

TABLE 3

The effects of fluidized bed drying on raw sugar crystal size

	Before Drying	After Drying
SGS	0,65	0,67
% Fines	28	21
MA	0,75	0,77
CV	28	27

Conclusion

Fluidized bed raw sugar drying at Sezela has proved very successful, although certain problems with peripheries are still to be solved. The plant has shown itself capable of operating satisfactorily under a variety of conditions.

Acknowledgements

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