DUST IN VERY HIGH POL SUGAR

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Abstract

Production of Very High Pol sugar, which commenced recently, has resulted in the problem of sugar dust generation. Analysis of the dust indicates the possible cause to be mechanical attrition of the sugar. By ceasing to use abrasive methods of conveyance the dust loading has been considerably reduced. In more persistent cases, other methods have had to be adopted, based on increasing the safety factor.

Introduction

With the introduction of Very High Pol sugar production in mid-1969 thought was given to the possibility of dust problems arising as the new grade would be very much drier than usual, the proposal being that the sugar would have a pol specification of 99,5 ± 0,2 and safety factor of less than 0,20.

The first consignment of the new Very High Pol sugar to reach the terminal confirmed these fears. Within a short period of the commencement of loading into Silo No. 2, the visibility was considerably reduced by a cloud of fine dust arising from the free-falling column of sugar and from the pile on the floor. Subsequent shipments have never presented quite such a picture although similar problems have arisen from time to time.

Of all the situations at the terminal the rail weighbridge intake station was the area most seriously affected. The room under the tippler bin housing the discharge conveyor had to be specially ventilated to improve working conditions as no appropriate facilities had been installed originally, and a considerable amount of dust built up on the conveyor steelwork and on the silo galleries in the roof. Owing to the proximity of the terminal to the bay and due to the hygroscopic nature of the dust, the material rapidly hardened and could not be removed easily. Apart from its nuisance value, the presence of suspended sugar dust presents a potential explosion hazard. Sugar dust on the shuttle conveyor busbars caused some difficulties with arcing problems and conditions in the molasses mixing plant were impossible.

Hazardous condition

Sugar dust in sufficient concentration is explosive and although most of the literature refers to refined sugar, the U.S. Bureau of Mines Report No. 5753 gives an explosibility index of commercial powdered sugar at 9,6 and raw sugar (light brown) at 8,2. An explosibility index of 1,0 is derived from a standard Pittsburgh coal, so the sugar dust hazard is considerbly greater than for coal dust.

Various values of minimum explosive limits are given in several articles but particle size, which is an important concentration condition, is often ignored. The smaller the particle size the lower the concentration required for minimum explosive level. This level is given at 20 g/m^3 for particles smaller than 100 μm[1] and is roughly equivalent to a visibility range of 2 m[2]. After six successive truckloads from Union Co-op had been unloaded, the under-tippler visibility was restricted to about 3 m, so a dangerous dust level is certainly feasible under such conditions. The terminal staff, on the grounds of safety alone, could reject such consignments from any mill should the condition re-occur in the future.

For an explosion to take place there must be:

(i) sufficient oxygen present to support combustion and also

(ii) an ignition source of sufficient temperature (350°C) and energy to ignite the dust cloud.

In the case of the terminal, armoured wiring, remote switchgear and a totally enclosed motor are used at all times to minimise the risk of an emergent spark.

Nature of the dust

Initial microscopic analyses of the dust showed extremely fine fragmented crystals indicating a possible source of the trouble to be mechanical fracture of larger crystals. Under a polarised light, most of the crystals polarised although some non-polarising particles were observed.

As a general rule, refined sugar is never conveyed by abrasive means due to the danger of fracture and subsequent deterioration of the appearance of the crystal and the production of fines. A similar rule should perhaps be adopted for Very High Pol sugar, not so much for appearance sake but rather to reduce the amount of fines produced and hence the amount of dust.

Action at dust producing mills

The Very High Pol sugar delivered to the terminal from Doornkop, Darnall and Union Co-op appeared to have the heaviest dust loading, and it was decided to eliminate the cause rather than to treat the problem at the terminal.

At Doornkop, the main cause of abrasion to the crystals appeared to be the use of the old Japanese assortment screw conveyor as the means of transporting the sugar to the storage bin. The installation of a belt to by-pass the screw conveyor had the desired effect and no further problems have been encountered.

In the case of Darnall, however, the danger of attrition appeared more serious as the Very High Pol sugar was transported by two screw conveyors, a bucket elevator and a third screw conveyor into a locally-made rotary dryer. The dust collector attached to this latter unit discharged copious quantities of fine white dust whenever a "balanced"

draught was used. As a temporary measure it was suggested that as the Darnall safety factor at that time was around 0,12, the safety factor could be slightly increased to over 0,15 or 0,16 by shortening the steaming time in the centrifugal baskets. The reasoning behind this move was that, while the sugar was not completely dry, the dust might adhere to the surface of the crystal or the crystal would not be as susceptible to mechanical fracture.

Occasional lapses in control have resulted in the odd "lumpy" truckload arriving at the terminal but with increase in safety factor, the dust problem from Darnall has been virtually solved.

Union Co-op remained the only other mill that required consideration and with the experience gained at Darnall it appeared only necessary to check Union Co-op's safety factor and increase it slightly to solve the problem. Eventually Union Co-op's consignments were arriving at the terminal with safety factors of 0,24 but the dust was as bad as ever.

Source location

At this point it was decided to try and pin-point the exact area of mechanical fracture in the process at Union Co-op. From the centrifugals the sugar was fed by a grasshopper conveyor into a bucket elevator and then through a short screw conveyor into a cascade-type rotary dryer. The product from the dryer was then conveyed by a belt direct to the storage bin.

The most convenient way of determining the amount of any particular size fraction in a crystalline substance is by conventional dry sieving but as the sugar dust is so fine, it is debatable whether or not weight variations would be easily detected in the relatively small sample used. If the presence of the dust is due to mechanical attrition, however, the change in amount could be inferred by a shift in the total size distribution of the sample. Fortunately a relative measure of dust loading in a sugar sample may be easily obtained by dropping a fairly large sample from a height of about two metres and comparing the amount of suspended dust formed around the pile with that from a "dust-free" sample.

A sample of the same sugar was taken at various points along the process and subjected to a size analysis by sieving. It was found that across the dryer, the $-42+100$ mesh size fraction increased from approximately 1,5% to about 4,7%, while the amount of fine crystals (-100 mesh) remained constant at 0,2%. Minor alterations were made to the dryer in order to reduce the retention of the sugar at the discharge side and the direction of rotation was reversed to reduce the height from which the sugar cascaded down within the drum. Further sieve analyses showed much less attrition but the "drop" tests indicated that the dust level still remained serious.

To determine whether the dust was possibly formed in the centrifugal baskets due to fracture of large crystals by excessive gravity forces, the speed of the baskets was reduced but this had limited or no effect on the problem. A microscopic check on the pan floor showed a considerable amount of false grain, conglomerates and non-sucrose matter but no definite source could be established. Due to the predominant sucrose nature of the dust, it was felt that if the dust was formed on the pan floor, it would tend to grow during the remainder of the boiling cycle and in the crystallizers and appear in the final product as small crystals rather than as fine dust.

A chemical analysis of a sample of Union Co-op sugar and associated dust had the following properties:

	V.H.P. sugar	*"Dust"*
Pol	99,36	89,96
% moisture	0,12	2,48
Aconitic acid	0,058	0,138

The presence of this impurity and its wide-spread distribution in the industry during the past season indicates a possible cause being inherent in the juice treated, but this is by no means conclusive.

Mechanical dust removal

It was then decided to physically remove the dust from the sugar. Screening a portion of the sugar on a pilot-scale Rotex screen proved ineffective for, despite the removal of a quantity of small crystals, the dust tended to remain in suspension above the main body of sugar. The relatively light weight of the dust particle tends to make any form of separation by gravity inefficient and some form of elutriation is preferred. An inspection of the fluidized beds at Gledhow and Sezela confirmed the ability of this type of equipment to remove the small particles causing the dust and recommendations were made accordingly. The fan horsepower required, however, presented a problem as Union Co-op, at the time, had limited electrical generating capacity.

In the meantime, following the success of Melville in containing their dust by the introduction of a small trickle of water on to the final product, Union Co-op arranged to feed their sugar into their old Japanese Assortment screw conveyor and add a thin trickle of 70°Bx. B sugar syrup on to the sugar. The screw conveyor discharged directly into the storage bin above the S.A.R. loading siding. The results are excellent, the dusty sugar as it pours into the screw conveyor becomes "dustless" half way along the length of the conveyor and remains in this condition until it reaches the terminal. There is no detectable change in the appearance of the crystals or in the analysis from the terminal.

Conclusions

Occasionally a consignment of sugar from a particular mill is reported as dusty by the terminal but invariably, on analysis, the safety factor is too low and the mill concerned is notified and the nuisance stops once appropriate control measures are taken. Generally, the dust may be contained by making the sugar slightly moist by allowing the safety factor to increase towards the upper limit of the specifications while, in the more persistent cases, the crystals may have to be coated with a small amount of appropriate syrup.

The major cause of the dust is still at present unknown although there is no doubt that mechanical abrasion is the source of some of the dust. The removal or replacement of any "abrasive" piece of equipment is therefore strongly recommended.

REFERENCES

1. Edwards, R. E., and Cunneen, E. W. P., 1968. The Dust Explosion Hazard in Sugar Handling. Sug. Ind. Tech. 27: 44-59.
2. Allen, W. A. R., 1964. Sugar Dust Explosions. Sug. Ind. Tech. 23: 174-175.

Discussion

Mr. Cargill (in the chair): Is sugar temperature important in connection with dust formation? We think that when sugar cools dust adheres to the crystals and avoids fall-off away when being off-loaded. We therefore cool sugar as much as possible.

Mr. Allan: We do not have any figures but high temperatures would cause drying on the surface.

Mr. MacGillivray: Has any thought been given to measuring dust at the terminal? In order to draw up possible future specifications it will be necessary to have accurate measurements.

Mr. Fitzgerald: After consideration it appears that only an optical method could be used, which would give a relative measure only. This will be investigated further.

Mr. Alexander: We carried out work at Darnall based on information from a Swedish paper which referred to refined sugar, as there is not all that difference between VHP and refined sugar. This suggested that dust was caused in centrifugals due to fracture of crystals, particularly conglomerates.

We were hampered by lack of suitable measurements but it appeared that at a low gravity factor there was less fined grain and less dust was formed.

I notice that in the analysis of dust on page two about 7,2% is not accounted for and I would appreciate further information about this.

Mr. FitzGerald: The balance of 7,2% is nearly all bagacillo. This is mainly because the sample was obtained at the factory.

Mr. Francis: In America screw conveyors are often used for refined sugar and there is also bulk carriage of sugar in rail cars but they do not seem to have this dust problem. I think grain size could be an important factor.

Mr. Girdler: At Amatikulu last year we steamed our centrifugals with vapour instead of live steam but in the course of these trials we did not notice any dust formation in the centrifugals.

At one stage during floods last year when the factory had stoppages and there was trouble with pan boiling we did get complaints from the terminal about dust, but as soon as the factory operations returned to normal the complaints ceased.

We do try and avoid breakage of grain after sugar leaves the centrifugals and we do pay particular attention to pan boiling in order to prevent dust formation.

Mr. FitzGerald: It has been mentioned in a previous paper that small grain causes dust because of specific surface area. Yet, strangely, last season the factories with dust problems had grain sizes that were larger than average.

Mr. Jennings: If centrifugals run at a very high speed they will run for a short period and at a low speed they will run for a long period, so presumably the same amount of dust will be formed.

Mr. Muller: In the tests at Darnall we found two distinct types of dust. One type had a perfect crystal formation but the other consisted of damaged crystals.

In the paper it says that Darnall increased the safety factor by shortening the steaming time in the centrifugal baskets. In actual fact it was increased by switching off the fans in the dust collector.

Mr. FitzGerald: The fact that there are two types of dust might explain why measures taken at one factory are not successful at another factory.

Mr. Radford: At the terminal five tons of dust, accumulated over half a season, were swept up in one silo.

Mr. Buchan: Possibly an air slide classifier could be used for measuring dust because of its reduced retention time compared with the normal type of fluid bed.

Mr. Cargill: To sum up, it appears that we should concentrate on good boiling, handle sugar carefully, keep it cool and where possible eliminate the trouble at source. The use of an air slide classifier should be considered.