

NOTES ON AIR POLLUTION IN THE SUGAR INDUSTRY

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Summary

A topic currently commanding urgent attention with the proposed scheduling of the sugar industry in terms of the Atmospheric Pollution Prevention Act is discussed in general terms. A variety of causes and remedies are commented upon and fields for further research suggested in the hope of stimulating fruitful discussion.

Introduction

On the morning of 10th December, 1969, a number of persons interested in the reduction of air pollution caused by boilers in the sugar industry chanced to arrive at the Engineers' Offices, Tongaat, simultaneously and the opportunity was taken to convene an informal forum for discussion of this vexed topic. This paper is a direct result of those discussions and much of what follows forms a synthesis of ideas expressed by those present, who were:—

Mr. N. Allan of the S.M.R.I.

Dr. E. C. Halliday of the C.S.I.R.

Mr. N. Boegman of the C.S.I.R.

Mr. N. Magasiner of John Thompson Africa (Pty.) Limited.

Mr. J. Michley of John Thompson Africa (Pty.) Limited.

Mr. J. van Dokkum of the Tongaat Sugar Company.

Mr. B. St. C. Moor of the Tongaat Sugar Company.

Dr. Halliday is the Chief Air Pollution Control Officer with the C.S.I.R. and he and Mr. Boegman have been charged with the task of investigating and combating this problem in the sugar industry. Their visit to Tongaat on this occasion was for purposes of preliminary fact-finding and problem assessment.

Mr. Magasiner and Mr. Michley had been involved in association with Tongaat Sugar Company with investigations into means of preventing smuts from bagasse-fired boilers and had been conducting experimental work on a pilot plant at Tongaat.

Perspective

Air pollution in general is undesirable when one or both of two circumstances prevail. These are, first, when it forms a health hazard (e.g. poisonous gases); and, secondly, when it forms a social amenity hazard (e.g. unsightly, light obstruction or dirt fall-out).

In the sugar industry the problem is almost entirely of the second type, and is primarily associated with the fall-out of incompletely combusted particles ("smuts") rather than with the true "smoke". The remedy lies either in prevention, by avoiding the generation of smuts (Generation) or in cure, by removing generated smuts from gases before their release (Removal).

Generation

1. Bagasse as a fuel presents problems. With the miller pushing mills to high capacities, high moisture contents can be expected (South African moistures tend to be higher than most). Further, bagasse is generally a non-homogeneous fuel, with heavy and light fractions, large and small particles inter-mixed. These properties are not conducive to complete and even combustion, but to overcome these limitations of bagasse as a fuel is probably too costly and too complex to be a feasible solution to the problem.

2. In similar vein, the presence in South African bagasse of a relatively high volume of trash residue, which is light and flakey, could be aggravating. A change in the basis of cane payment may help here.

3. In any bagasse-fired boiler or incinerator, adequate furnace area is essential in order to ensure a low gas velocity and thus minimise carry-over. Unfortunately it is seldom easy to redesign existing furnaces.

4. Adequate height of the furnace is also important, in order to allow a sufficient period of time before contact with the tubes and extinction of the flame front. Any incompletely burnt particles at this stage will carry over as smuts.

5. Another contributory factor to smuts generation can be the lack of draught control on a boiler. Fitting of such control may often be simple and inexpensive.

6. Spreader stokers are far greater offenders than the hearth-type furnace as the principle of combustion in suspension is bound to induce carry-over. However, it is accepted that spreader stokers are essential for dual fuel (coal/bagasse) boiler firing.

7. Boiler selection based exclusively on cost must cause boiler designers to rate their designs immoderately. It is recommended that sugar engineers include the requirement that the plant be "smut-free" in tender specifications for new boilers. Standards of freedom from smuts for bagasse-fired boilers have not yet been defined, but it is hoped that Dr. Halliday and his colleagues at the C.S.I.R. will be able to assist in this regard.

8. Boiler users are also to blame for accepting situations of under-capacity, in which boilers are forced beyond their design loads. Perhaps this is the greatest single cause of the smut nuisance in the industry.

9. Another major cause of smuts carry-over from certain boilers is the lack of air heaters. The relatively moist bagasse found in the S.A. sugar industry will not burn to complete combustion in most boilers unless combustion is initiated with pre-heated air.

10. Correct training and supervision of boiler operators in such matters as fuel bed levels,

steady fuel supplies, fuel distribution across the furnace and draught control is also essential.

11. It has been suggested that the common practice of mixed firing of bagasse and coal causes more smuts than either fuel used on its own, and should be avoided. To avoid this practice may require larger bagasse storage facilities with improved recovery plant.

It is worth noting that many of the remedies proposed in this section are inexpensive, and often have side benefits which would enable the measures to pay for themselves.

Removal

If measures to prevent the generation of smuts are either not feasible or unsuccessful, then the less satisfactory solution can only lie in their capture and removal from the flue gases. Comments to be made on some methods tried are:—

1. Spinners and cyclones are of dubious effectiveness in dealing with the relatively large particles of low density which constitute the bulk of bagasse smuts.

2. The cost of electrostatic precipitators, which would probably be effective, is prohibitive (one price quoted was nearly three times that for an equivalent cyclone system).

3. Partial success has been achieved at Tongaat using water sprays in a "smuts chamber". Essentials are adequate volume and dispersion of sprays, low gas velocities through the chamber (Dr. R. Morris has quoted a maximum of 3 m/s) and a brick-, concrete- or stainless steel-lined stack to resist internal corrosion. In order to provide sufficient water a recycling system with small make-up and leak-off was instituted. Smuts screened from the spray water is disposed of with the factory filter cake. Problem areas in the system are choking of the sprays, pump maintenance and screening the smut-bearing water. These have now been largely overcome.

4. A system of removal being tried in Australia involves bubbling the flue gases through about 25 mm of water. In addition to the disposal and stack corrosion difficulties, this method also imposes an additional head on the induced draught fan and would normally require an increase in power here of about 15%.

5. Engineers of John Thompson Africa have recently carried out extremely promising experiments at Tongaat involving filtering the flue gases through various screening media. On the pilot plant most success was achieved using a 40-40 per inch mesh stainless steel vibrator screen as filter medium. This system virtually guarantees the dry removal of 99% by volume of all particles over 0.25 mm in size, and a large proportion of all finer smut particles. The disadvantages of the system would appear to be cost (R20,000 to R30,000 for a fully automatic unit for a 40 t/h boiler) and increased I.D. fan power requirements owing to the pressure drop of approximately 25 mm w.g. across the filters.

6. In a very few instances, an acceptable alternative to removing the smuts could be to spread it a bit more thinly over the downwind terrain. One way to do this is to increase stack heights.

Conclusion

Dr. Halliday has persuaded the South African Sugar Millers' Association to agree to the industry's being declared a "Scheduled Industry" in terms of the Atmospheric Pollution Prevention Act. All mills will thus be required to take stock of their position in the very near future. To assist in this, Dr. Halliday proposed the formation of a study group comprising mill engineers together with S.M.R.I. and C.S.I.R. representatives. This group has been formed and with the assistance of Dr. Halliday and his staff should be able to play a constructive part in "cleaning up" the skies over the industry.

The foregoing discussion demonstrates that solutions need not be very costly and could well be self-financing. Study avenues in this field could include quantitative studies of satisfactory furnace design principles; methods of measuring stack emissions; criteria for satisfactory stack conditions; the development and evaluation of smuts removal systems; and alternative uses for bagasse to obviate the need for incineration.

Discussion

Mr. Magasiner (commenting on his slide projections): I agree that the most intelligent way to solve the problem is to eliminate the cause. Correct furnace design goes a long way to achieving this. At our company's second International Conference on Boiler Plant for the Cane Sugar Industry in Australia last year the factors affecting carry over were discussed at length and parameters were quantified using an acceptable visual stack emission as the guiding criterion.

Apart from furnace configuration, bagasse moisture content and grading were high-lighted as the most important single factors affecting performance. The lower the moisture content, the lower the smut emission from a given unit. The University of Natal is at present attempting, on our behalf, to formalise the empirical data which we have gathered together.

By the way, there was strong evidence presented at our conference to indicate that a correctly designed hearth type furnace set in a Dutch Oven was the most effective available from a grit and smut suppression and combustion point of view. Initial cost, size limitations and maintenance unfortunately ruled it out as a commercial proposition under present-day conditions.

While mechanical collectors of the cyclone or multi cyclone type are capable of collecting a substantial proportion of the denser grits, they are unable to collect the smut particles which have a very much lower density.

The performance of a collector drops as the density of the particles to be collected is reduced. If the aerodynamic drag on the particles is high, as is the case with bagasse smut, the reduction in performance is very much greater and the collector efficiencies are reduced even more radically. To aggravate the problem still further, any air leakage into the collector through the dust discharge system causes a substantial reduction in performance.

The problem has been analysed in detail by the Sugar Research Institute in Mackay, Australia, who

have concluded that wet collectors of the scrubber type are the only suitable machines available at present.

The wet type collector, however, suffers from a number of very serious disadvantages. These are:—

- (a) The gases leaving the collector are saturated. The ductwork, induced draught fan and chimney must therefore be protected against corrosion. The ducting and chimney can be Gunnite lined but this is expensive and would probably have to be renewed every four odd years. The induced draught fan would have to be made of stainless steel.
- (b) The water absorbed by the gases would amount to approximately 10%—15% of the M.C.R. evaporation of the boiler plant.
- (c) In order to avoid creating a water pollution problem, the water used in the collector would have to be filtered and re-circulated. A simple vibrating screen appears to be quite adequate for this duty. The solids contents of the re-circulated water apparently stabilises at about 0.3% by weight.

Because the wet collector in solving the smut emission problem creates a number of expensive subsidiary problems, it seems worthwhile to spend a bit more time in trying to make the dry collector work before admitting defeat.

Towards the end of last year, we tested, in conjunction with Tongaat, a filter device. Unfortunately, for reasons beyond our control, our experiments were curtailed before we were able to finally establish ultimate performance limits.

The preliminary results appeared to be reasonably promising and indicate that further work is warranted. Provision has been made in the ductwork of the new boiler being installed at Tongaat to carry out these tests.

Having collected the grit and smuts the problem of disposing of them remains. They must be damped down to eliminate a fire hazard and to prevent them blowing about in the wind. The mechanical design of equipment to successfully handle these wastes is an interesting problem in its own right and one which I feel should be divorced from the broader problem of collection.

Mr. Buchanan (in the chair): For avoidance of air pollution, should trash be burnt in the field or in the factory furnace?

Mr. Moor: Burning in the fields does not overcome the problem of pollution, it merely spreads it over a wider area, although the fields may at least derive some benefit from the burnt carbon particles.

Mr. Kramer: How high does Mr. Moor think the bagasse furnace should be in relation to the furnace grate area?

Mr. Moor: There are no criteria that I am aware of giving ratio of furnace area to height or furnace volume to calorific output of the boiler at M.C.R.

I think that air pollution study group should investigate this.

Mr. Allan: Before we do anything, we must establish scientifically a satisfactory level of emission.

We can improve existing stack conditions by taking note of all the points Mr. Moor has raised.

An elementary way to begin is to pay more attention to the boiler house.

Some sugar factories have already installed dust collecting equipment.

Fortunately we have a reasonable amount of time to set our houses in order.

I take issue with Mr. Moor on one point. I am not convinced that, if a spreader stoker boiler is fired correctly and its fuel to air ratio is correct, that it is a worse type of unit than any other.

Mr. Moor: I would agree with Mr. Allen if he also mentioned design of the spreader stoker furnace.

If two identical furnaces are fired, one with a spreader stoker and the other with a quiescent bed, then the spreader stoker will emit more from the stack than the other, because in the quiescent bed there is a period for bagasse to be heated before going to the gas passes. Therefore, it requires less time to complete its combustion and is likely to undergo more thorough combustion. Often with spreader stokers, furnace areas and furnace heights have been kept to the barest minimum with an eye to cost and no account has been taken of pollution.

Mr. McLunan: With coal, are not toxic effects more important than visible emission, and does this not apply to bagasse as well?

Mr. Moor: Apart from the central refinery in Durban, most sugar factories only use coal intermittently as an auxiliary fuel. The factories are generally situated out of town and I have not heard of any complaints about toxicity of flue gases. The toxic effects of coal gases are mainly associated with concentrations of sulphur dioxide. Bagasse, unlike coal, contains only negligible quantities of sulphur.

Mr. van Hengel: To limit increased use of coal in the sugar industry as bagasse utilisation projects develop, we should investigate bagasse saving methods and endeavour to make changes in process operations rather than boiler operations.

Mr. Dick: Have any attempts been made to pulverise bagasse to make it more uniform before firing?

Mr. Magasiner: An enormous amount of horse power would be required for this purpose.

Mr. Strong: Pollution is a matter of economics. When a new boiler is required the first consideration is price. It is difficult to convince management to spend more in order to prevent pollution.

Mr. Allan: One of the objects of the study group is to set up reasonable criteria which we know will give us an acceptable smut emission.

Boiler manufacturers in future will only be able to sell boilers to the sugar industry that comply with our reasonable standards.

Dr. Mansfield: Surely the important point is the concentration of material coming down — and what goes up must come down!

Mr. Allan: That sounds correct but it is possible to do as Rand Carbide did, namely, build an enormously high stack so that emissions simply disappear into the atmosphere. The cost of the stack was, however, very high.