PNEUMATIC BOILER ASH DISPOSAL PLANT

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Abstract

The following paper is an attempt to describe the installation and unsuccessful commissioning of a pneumatic boiler ash disposal plant at the Amatikulu Mill of Huletts Sugar Limited.

The paper describes the proposed method of operation, the problems occurring during commissioning and the reasons for the failure of this type of system as applied to a bagasse fired boiler.

1. History

1.1. *Original disposal plant*

Initially the boiler fine ash was trapped by means of water seals, the resulting slurry being fed to dunder water and hence disposed of by field irrigation.

This method gave little operative trouble, except that dunder drains tended to block occasionally and nozzle wear on the irrigation sprays together with pump wear was rather excessive.

1.2. *Alternative system*

During the 1966/67/68 crushing seasons a hopper fitted with a double flap was used in place of the water seals. With this method one valve always remains closed. The system had the following disadvantages:

(a) considerable dust problem due to hopper leakage (difficulty in maintaining an air-tight seal was experienced).

(b) due to these small air leaks, fires occurred in the hoppers.

(c) increased air pollution.

(d) fires caused severe distortion of hoppers.

(e) manual removal of fine ash and dumping on a nearby site caused considerable dust and air pollution.

1.3. *Modified original system*

A neighbouring cane farmer lodged an official complaint about the excessive "fall-out" on his farm house. Because of this complaint and because of the general mess caused in and around the mill area, it was decided to return to the well proven hydraulic fine ash removal system. New hoppers and water seals were fitted and a suitable pump was purchased which fed the ash slurry via a 75 mm pipe to a dam adjacent to the excess bagasse dumps.

1.3.1. A disposal problem now presented itself as after a few months it was necessary to excavate extra dams to contain the ever increasing volume on the ash dump. Some pollution of the river occurred due to overflow.

1.4. *Other alternatives*

Other methods of disposal were sought, the most practical and beneficial being to mix the fine ash with milo. This, however, required a means of removing water from the ash. Various methods were examined and a few of the more promising methods were tried out on a pilot plant scale. None of these, however, proved feasible.

2. Pneumatic ash removal

2.1. *Advantages*

Towards the end of the 1968/69 crushing season our attention was drawn to a pneumatic ash removal system of a type in common use overseas, particularly in the U.K. and U.S.A. The system promised many attractive features in that:

(a) it was completely automatic, requiring only occasional operative checking by boiler house personnel;

(b) that it was a completely dust free closed system, the ash being extracted direct from the side of the hoppers and taken through a continuous pipe to be discharged where required;

(c) that the system required no water for its operation, the ash being conveyed in an air stream, and

(d) that being dry it could be fed directly to the milo conveyor and hence disposed of in an economical and beneficial manner;

(e) we were assured by the manufacturers of this plant that not only could we convey ash from the rear fine ash hoppers, but that undergrate and front hoppers could also be emptied.

2.2. *Decision to purchase plant*

A decision to install this plant was made in May, 1969, after samples of boiler ash had been examined by the company manufacturing the plant. Delivery was expected in October, 1969.

2.3. *Description of plant*

The plant is divided into two systems:

(a) suction system;

(b) blower system;

(a) Suction system

Discharge of ash from each hopper is accomplished through extraction nozzles (see Figure 1). A vacuum of some 300 mm Hg is applied to the nozzles by means of a positive displacement (rootes type) pump. Replacement air from the surrounding atmosphere is directed to the mouth of the nozzle via a valve and then an annular space surrounding

the delivery pipe. Air passing through this nozzle attracts solid particles in the vicinity of the nozzle entrance and these particles having become air-borne are then pneumatically transported to a central collecting hopper situated at a convenient station in the boiler house.

Each boiler hopper is emptied in succession, the cycle time being controlled from a bank of adjustable cams driven by a synchronous motor, the cams operating electrical contacts which in turn operate pneumatically controlled air entry and slide valves at each hopper. The delivery pipes from each set of boiler hoppers feeds the air/ash mixture into the collecting hopper (see Figure 2) where the solid particles are separated from the air by passing the

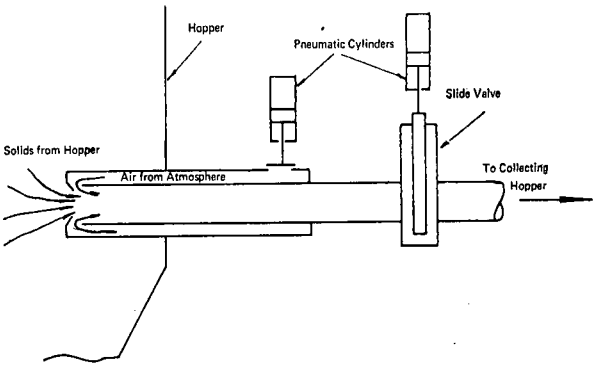

FIGURE 1: Diagrammatic sketch of extraction nozzle.

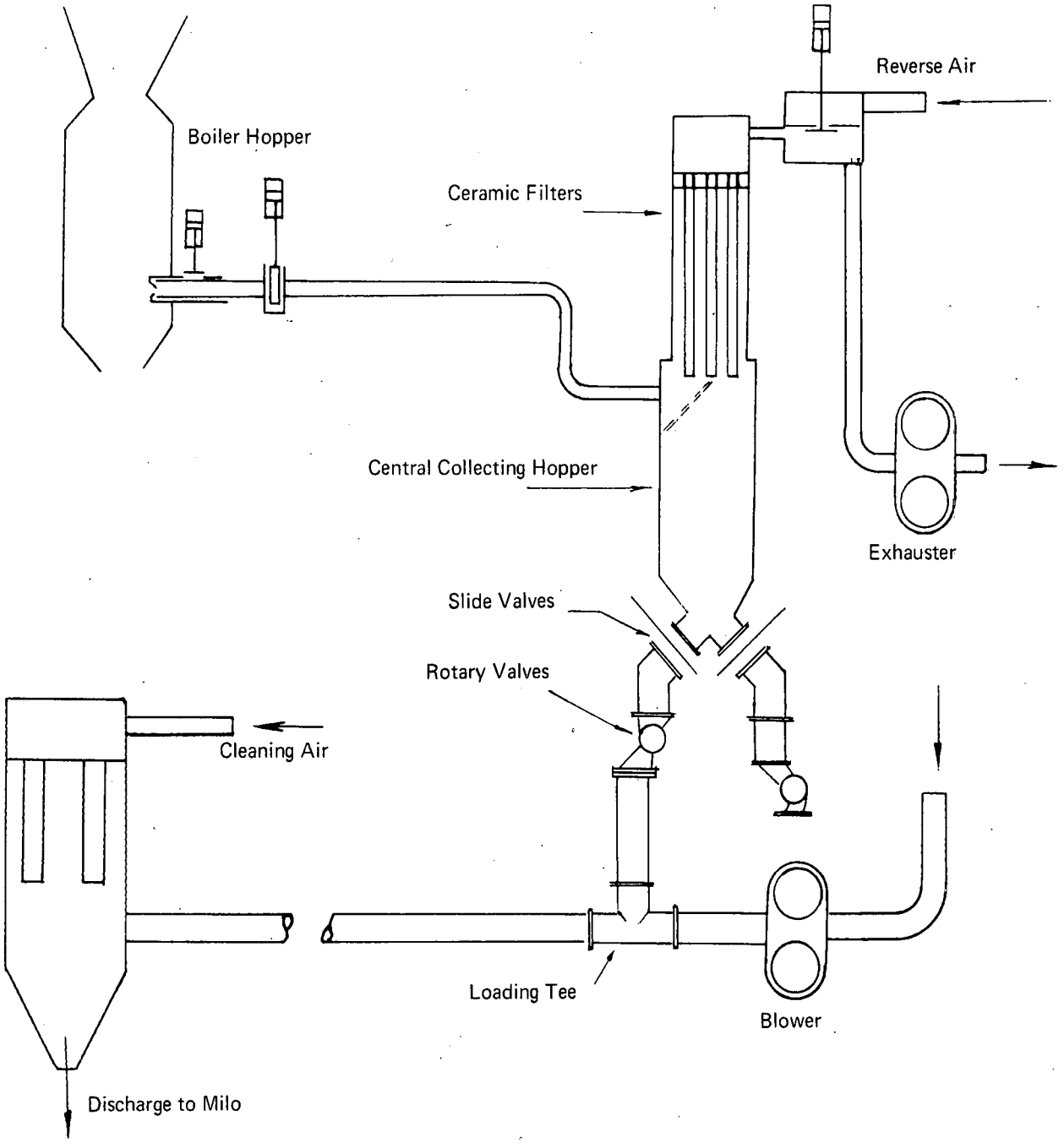

FIGURE 2: Diagram of ash removal plant.

air through a bank of ceramic filters. The air, having passed through the filter is drawn out through the exhauster to atmosphere.

A reverse air cleaning cycle is interposed after the emptying of the hopper of all four boilers. This effects a clearing of the filter surfaces by allowing air from the atmosphere to flow rapidly through the bank of filters to neutralize the vacuum existing in the collecting hopper.

(b) Blower system

The fine ash which has been transported from each boiler hopper to the collecting point is now fed via a rotary valve into a "loading tee" which delivers the ash into the blower system transporting pipe. A positive displacement pump identical to the exhauster draws air in from the atmosphere and delivers the air past the "loading tee" and hence transports the ash out to a discharge hopper situated on the milo bin, a distance of some 200 metres. Once again it is necessary to separate the fine ash from its transporting air stream and in this case fabric filters were employed. A cycle controlled by a second timer cleaned these filters periodically with compressed air.

3. Initial teething problems

3.1. *Trial runs*

Towards the end of the 1969/70 crushing season, trial runs were attempted, first on the undergrate hoppers and then on the front hoppers, but met with little success.

It was apparent that ash was, for some reason, not moving towards the extraction point at the entrance to the nozzle, and to examine this closely a sealed adjustable viewing tube with inspection light was inserted into the hopper so that the nozzle entrance and surrounding ash could be seen under running conditions.

3.2. *Air leaks*

At this stage it was felt that malfunctioning of the system was caused in nearly all instances by air leaks. After curing these leaks, it was still found impossible to continually extract ash from the hoppers, even after the exhauster pump speed had been increased.

3.3. *Run of blower system*

The blower system failed to extract ash from the collecting hopper. Re-design of the loading tee improved the flow of ash into the transporting pipe.

3.4. *Failure of filter elements*

In January, 1970, the first of a series of ceramic filter tube failures occurred. Twelve of the 18 filters fractured at various points along their length, with a typical 45° fracture plane.

3.5. *Modification to baffle plate*

The baffle plate (shown dotted in Figure 2) was enlarged and moved upwards so as to eliminate the possibility of breakage caused by the impingement of ash particles on entering the collecting hopper.

3.6. *Clinker breakers*

The company manufacturing the equipment wrote admitting failure of the plant to extract undergrate ash and suggested the purchase of clinker breakers to solve the problem of extraction from these hoppers. Decision to purchase these was delayed until such time as the plant could otherwise be proved effective.

4. Off-crop alterations

4.1. *Fine ash hoppers*

During the off-crop period, it was decided to concentrate all efforts entirely on the rear fine ash hoppers, principally because these hoppers constituted the main source of pollution and plant uncleanliness, and it was felt that more success in extraction of this ash was likely due to its finer nature. Fine ash hoppers were installed (see Figure 3) and both the undergrate and front grate hopper extraction points were blanked off.

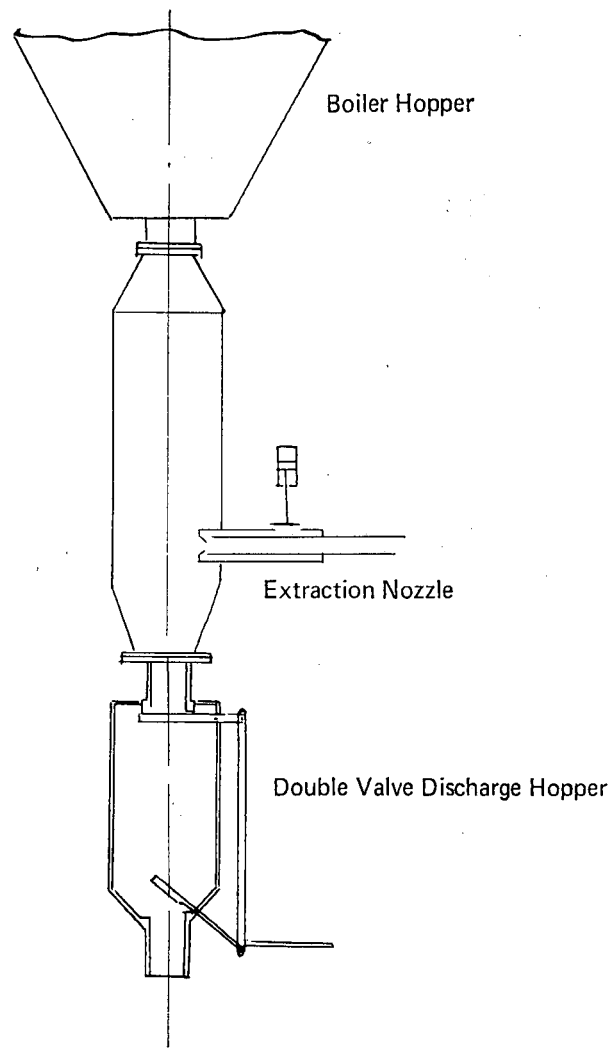

FIGURE 3: Details of fine ash hopper.

4.2. *Valve additions*

Since the three hopper transporting pipes joined into a common line before entering the collecting hopper, it was thought that while ash is extracted from one hopper, the system might also draw in flue gasses from within the other two hoppers. Slide valves were consequently inserted in each pipe from all hoppers.

5. 1970/71 Crushing season

5.1. *Re-occurrence of filter breakage*

Just after the commencement of the crushing season, the second filter element failure occurred. On this occasion eight of the filters were affected. Several theories were advanced on the cause of element breakages as follows:

(a) mechanical damage from the impingement of solid particles on entering the collecting hopper;

(b) thermal shock when the sudden air temperature change associated with the reverse air cleaning cycle occurs;

(c) mechanical damage resulting from possible shock waves caused at cycle changes, particularly the cleaning cycle operation, when the internal vacuum is suddenly released;

(d) intense heat impinging on elements, caused through the bagasse particles burning whilst in transit through the piping system to the collecting hopper or from fires occurring in the fine ash hopper caused from air ingress being transported to the collecting hopper.

5.2. *Solutions*

(a) above, was, as already discussed, dealt with by the installation of a protective baffle.

(b) and (c) were at this stage dealt with by restricting excessive filter element movement by means of a supporting wire framework. Additionally, the air required for the reverse air cleaning cycle was taken from an adjacent boiler secondary air duct and passed via a short pipe column to the reverse air valve box. The object here was to feed in reverse air with a temperature similar to that of the transporting air from each fine ash hopper. Thermal shocks would thus be largely eliminated. (N.B. The manufacturers of this equipment were informed by their principals, overseas, that only one filter element had ever broken in any of their numerous installations. These were, however, on coal fired boilers.)

(d) at a later date long rods were inserted through the centre to strengthen the filters.

(e) many fires, referred to above, occurred in all the fine ash hoppers and caused considerable distortion of these hoppers.

The central collecting hopper also became very hot at one stage and burned a considerable amount of paint from one side of the hopper. At this stage it was decided to remove a flanged hopper joint and to weld it permanently to prevent air ingress. More attention was devoted to the extraction nozzle valves to further eliminate air leaks.

5.3. *Bridging of ash*

After more filter elements had been hurriedly obtained and installed, fresh attempts were made to run the plant. It was evident now and from our previous observations that the ash tended to bridge across the extraction nozzle entrance or to form a "rat-hole", so preventing movement of the material. (N.B. An analysis of ash from the fine ash hopper showed that approximately 90% of the total, by volume, was in fact small particles of unburnt bagasse, the remaining 10% being mostly fine sand. By weight, the bagasse constituted only 15% of the total.) Again several theories were advanced as to why this should occur, these principally being:

(a) that the intermittent nature of the extraction cycle allowed sufficient build up of ash so preventing an easy flow towards the nozzle entrance, and

(b) that any slight burning of the bagasse particles tended to form a complete mass of particles lightly bonded together by the burning process.

5.4. *Methods of agitation*

To overcome the inability of ash to flow towards the extraction nozzles, vibrators, internal chains and stirring paddles were fitted to each fine ash hopper. Finally, the hoppers were re-designed to give greater vibration to the hopper sides. The time cycle was also altered to give different extraction durations. In order to keep the filter elements clean and hence keep a high operating vacuum, a reverse air cleaning cycle was arranged after each hopper extraction cycle. After these and many other minor modifications no permanent improvement in the pulling away of ash was noticed.

5.5. *Pipe blockages*

Several blockages of the transporting pipe occurred. These seemed to be caused mainly through sand settling on the bottom of the pipes and gradually restricting the flow.

5.6. *Rotary valves*

The two rotary valves which discharge ash from the central hopper needed frequent adjustment of their sealing blades, due to wear.

Any leakage here represented a loss of vacuum to the extraction system and could also cause entry of air from the blower system.

5.7. *Commissioning engineer*

As the end of the crushing season was rapidly approaching, a commissioning engineer from the manufacturers was given the task of getting the plant operative before the season ended. He took more vacuum gauge readings, again uprated the pump speeds and both motor sizes, changed still further the sequence timing with the result that for the third time an almost complete set of ceramic filter elements broke. By joining filters together and indeed lengthening most of them by 50% to give an increased filtering area this problem was overcome. Again the plant was tried, with again no success.

5.8. *Fires and pipe wear*

Fires still occurred with alarming frequency in the fine ash hoppers, as they choked because extraction of ash was minimal and it was then reported that some bends in the transporting pipe line were completely worn through from the abrasive action of the sand in the ash.

5.9. *Final attempts*

The pump fitted in the blower system was tried out in the exhauster system, since this pump was driven at a higher speed and had a larger driving motor. The piping was even further changed so that both pumps could be used as exhausters and two boiler hoppers were connected to each pump to give twice as many extracting cycles to each hopper. None of these modifications resulted in any improvement.

6. Conclusion

6.1. *Fine ash*

In our opinion, it was entirely the nature of the material being transported which prevented a workable system. The particles of unburnt bagasse were lightly charred on their surfaces and were in a very dry condition having been subjected to the drying action of flue gasses at some 470°C. All of the problems mentioned, particularly that of the build-up of ash and of fires in the hoppers, we feel, are entirely due to the obviously combustible nature of the material.

With coal fired boilers the resulting ash is presumably in a state of almost complete combustion and, therefore, lends itself to a pneumatic means of conveyance.

6.2. *Intermittent extraction*

The time duration of a complete cycle of hopper extractions was 15 minutes, and since each of the 12 hoppers was emptied in sequence, a build up of material obviously occurred. It was felt that had it been possible to continuously draw ash from each hopper, the plant may well have operated satisfactorily. This, however, was a completely uneconomical proposition since a separate exhauster would be required for each hopper.

6.3. *Unreliability*

The entire plant operation was of a most unreliable nature, although a few runs of up to two hours or more were achieved. It is felt that even had the plant been successfully commissioned, there were too many factors which could go wrong and would give continuous trouble.

6.4. *Filter elements*

Filter element breakage caused a great deal of wasted time and seemed a very vulnerable part of the plant. The filtering area was almost certainly too small as seen by the fall off of vacuum from 300 mm Hg to 120 mm Hg in around 30 seconds of extraction cycle time, which represented only one-sixth of the total cycle time.

6.5. *Rotary valves*

The rotary discharge valves seemed another source of constant trouble in that very frequent maintenance would be required.

6.6. *Capacity*

The rated capacity of the plant supplied was plus minus 5 tons per hour, moving ash from all hoppers on all four boilers. The measured quantities during trial runs amounted to 1,25 tons per hour, and for most of the time the plant was incapable of moving even this reduced amount.

6.7. *Pipe bends*

In total, the suction side of the system was in operation for some 144 hours and the blower side for 24 hours. Pipe bends in both systems had already worn through, conclusively proving that mild steel bends are not suitable for the pneumatic transport of this type of material.

6.8. *Unsuitable*

After 10 months of interrupted trials it is evident that a pneumatic ash removal system for a bagasse fired boiler is unsuitable.

Discussion

Mr. Gunn (In the Chair): When ash was removed from the hoppers in the boiler was this intended to prevent air pollution?

Mr. Kramer: It was hoped that installation of the plant would reduce air pollution but it was not anticipated that it would solve the problem entirely. Our main objective was dust free conveyance of smut from the boilerhouse to the Milo Disposal plant.

Mr. Hulett: It appears that your biggest problem was that you were handling unburnt bagasse instead of ash. The boilers at Amatikulu have two stages of grit refiring and the only way to get unburnt ash through is if there are holes in the cyclones or the discharge hopper is blocked. If this happens everything will come back into the second stage of grit refiring.

Mr. Wilson: All cyclones are in good condition and are working properly. Because of excessive tube wear in the boilers it has even been considered to cut out the grit refiring system altogether. The two stage grit refiring has never prevented unburnt particles getting through to the last hopper where considerable quantities are collected.

Mr. Warren: On start-up we had a lot of unburnt bagasse which filled up the hoppers so we had to fit an emergency discharge double acting valve.

Mr. Camden-Smith: The first problem is to convey the fly ash from the last stages of separation and the second problem is to convey the ash from the grate of the boilers.

This equipment appears to be wrong for the fly ash but might be suitable for the ash from the grate, which is more solid and heavier and may contain coal.

The best way to take away fly ash might be by means of a fan and rotary valve under each hopper.

Was there a dust problem where the ash was discharged?

Mr. Wilson: Extraction was tried unsuccessfully from the under-grate hoppers and the manufacturer's commissioning Engineers admitted failure of extraction, stating that clinker breakers were required.

The manufacturers said that the amount of heat

under each hopper would prevent the use of rotary valves, which are anyway very expensive.

There was a dust problem and a screw conveyor and water spray had to be used. These were fitted at the end of the discharge line i.e. on top of the Milo bin.

Mr. Pope: What did the project cost and who paid for it?

Mr. Kramer: Total cost was R18 000 and we are negotiating for refund of this amount and think we shall be successful.

Mr. Cranwick: What do the authors propose to do next?

Mr. Wilson: We have installed hydraulic water seals under each hopper and are using manual labour to empty the under grate and front grate hoppers.

All four boilers feed down into a rubber-lined pump and then to a fairly large separating tank at the back, which enables sand and other particles to settle to the bottom. This is removed by a scraper conveyor and dropped into the milo conveyor.

Mr. Kramer: The settling time after the sealing water has gone through the pump increases about fourfold as compared to settling time in a test tube.

Mr. Warren: It is advisable to let the slurry run through a DSM screen before it gets to the settling tank, to remove bagasse.