

A PERFORMANCE UPDATE FOR THE COLUMBUS PROJECT

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ABSTRACT

The Columbus Project is a refuse derived fuel/coal-fired municipal electrical power plant. The maximum daily refuse derived fuel (RDF) throughput is approximately 3000 TPD. The project was first started up in August 1983 at which time serious problems were encountered, primarily with the RDF fuel and ash systems. A major modification program was initiated in February 1985 and was completed in early 1987. Modifications were made to the RDF preparation systems, fuel feed systems and the ash system. Subsequent to the modification program, significant improvements in plant performance have been experienced. This paper describes the modifications which were made and presents overall plant performance as well as an analysis of individual plant components.

INTRODUCTION

Construction began on the Columbus Project in 1979. The plant was designed to produce and burn refuse derived fuel (RDF) with a peak RDF throughput of about 3000 TPD with all six boilers in operation. It was intended that coal be co-fired with the RDF in the ratio of 20% coal/80% RDF by heat input. Coal was initially fired in the boilers in December 1982 with the circuit breakers being closed for the first time on the turbine generators in June 1983. RDF was intro-

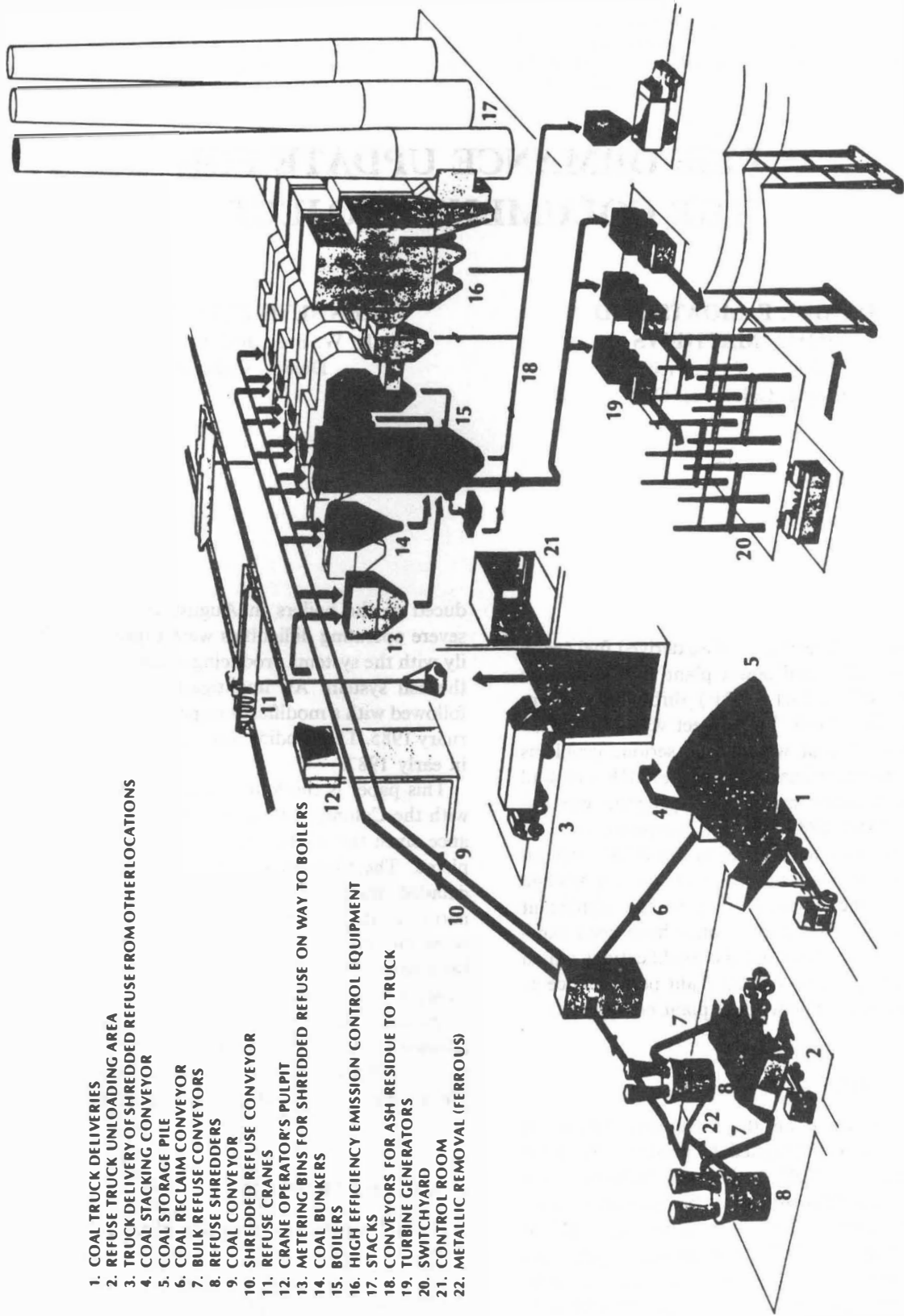
duced to the boilers in August 1983 at which time severe operating difficulties were experienced, primarily with the systems producing and handling RDF and the ash system. An investigation into the problems followed with a modifications program initiated in February 1985. This modifications program was completed in early 1987.

This paper is the fourth of four documents dealing with the Columbus Project and covers plant performance since the modifications program has been completed. The three preceding documents provide: (a) detailed descriptions of the facility; (b) describe the nature of the problems encountered; and (c) provide some interim information on plant performance. That information will not be repeated here, except as necessary for completeness. The purpose of this paper is to provide a brief recap of the modifications program followed by a description of overall plant performance as well as performance of individual components since the modifications program was completed.

PLANT DESCRIPTION

The following is a description of the plant as it was originally constructed.

The Columbus plant is situated on a 52 acre (21 ha) site on the south side of the City. A schematic of the overall plant is presented in Fig. 1.



1. COAL TRUCK DELIVERIES
2. REFUSE TRUCK UNLOADING AREA
3. TRUCK DELIVERY OF SHREDDED REFUSE FROM OTHER LOCATIONS
4. COAL STACKING CONVEYOR
5. COAL STORAGE PILE
6. COAL RECLAIM CONVEYOR
7. BULK REFUSE CONVEYORS
8. REFUSE SHREDDERS
9. COAL CONVEYOR
10. SHREDDED REFUSE CONVEYOR
11. REFUSE CRANES
12. CRANE OPERATOR'S PULPIT
13. METRING BINS FOR SHREDDED REFUSE ON WAY TO BOILERS
14. COAL BUNKERS
15. BOILERS
16. HIGH EFFICIENCY EMISSION CONTROL EQUIPMENT
17. STACKS
18. CONVEYORS FOR ASH RESIDUE TO TRUCK
19. TURBINE GENERATORS
20. SWITCHYARD
21. CONTROL ROOM
22. METALLIC REMOVAL (FERROUS)

FIG. 1 SCHEMATIC OF THE COLUMBUS REFUSE AND COAL FIRED MUNICIPAL ELECTRIC PLANT

The numbers referenced in the following paragraphs are keyed to the schematic.

Coal is delivered by truck (1) to a coal storage pile (5). The coal is transferred to the pile by the coal stacking conveyor (4) and then from the pile by the coal reclaim conveyor (6) to the coal conveyor (9) which loads the coal bunker (14) for each boiler.

Bulk refuse is trucked to a covered tipping floor area (2). Bulk refuse is transferred by front end loader to pan conveyors (7) which feed two Heil 92B vertical shredders (8). The shredders are rated at 60 TPH at 90% minus 3 in. particle size. The shredded refuse passes through a ferrous metal removal process (22) which removes some iron from the refuse. Shredded refuse is transported from the shredder station to the boiler house by the shredded refuse belt conveyor (10). Shredded refuse may go to RDF surge bins (13) or to the storage pit, which has a capacity of 7500 tons (6810 t).

The City operates three satellite shredder stations which produce shredded refuse which is trucked to this site (3) and dumped into the storage pit. Each of the satellite stations has a cross belt magnet for ferrous metal removal.

Two bridge cranes (11) are used to transfer the shredded refuse to the surge bins (13) from the pit. The surge bins discharge onto belt conveyors, which discharge the RDF into feed chutes at the boiler front. The crane operator's pulpit (12) allows the operator to observe and manage the pit contents.

The six boilers (15) are capable of producing 165,000 lb/hr (74,844 kg/h) of steam each. The 700 psig (4823 kPa), 725°F (388°C) steam is used to drive three 30 MW steam turbine generators (19). The power produced is distributed to the City's existing retail customer base through the switchyard (20).

Mechanical dust collectors and high efficiency electrostatic precipitators (16) are used to reduce particulate emissions to acceptable levels. The clean flue gas is discharged to the atmosphere through three 272 ft (83 m) tall stacks (17).

The bottom ash is quenched with water in two basins located under each boiler and then transferred by conveyor (18) to an ash storage bunker. Fly ash is conditioned with water and combined with the bottom ash on the conveyor (18). Ash from the boiler hoppers and economizer is reinjected into the furnace.

MODIFICATIONS PROGRAM

A detailed investigation of the problems at the Columbus plant began in mid-1984, and revealed a large

number of problems, primarily with the RDF preparation and feed systems and the ash system. These problems were prioritized in terms of their impact on plant performance. A modifications program was initiated in February 1985 for the main plant to remedy the most severe problems. Modifications at the main plant were essentially completed by February 1987. The modification program for the satellite shredder stations is currently in the design stage. The following is a list of the major modifications:

(a) Main Plant

(1) A program was instituted to optimize the performance of the vertical shredders in terms of particle size and throughput. Various type of hammers and hammer patterns were tested.

(2) A disc-screen was installed downstream of the north shredder magnetic separator assembly to reduce or eliminate the passage of oversize materials to the boiler fuel feed system. A single system was installed to evaluate performance of this arrangement. A return conveyor was installed to carry the oversized material from the disc-screen back to the main shredder plant tipping floor.

(3) The existing "hockey stick" magnets were replaced with stronger constant-field magnets. These new magnets were installed in the same space envelope as existed for the original "hockey stick" magnets. The original "hockey stick" magnets were efficient in removing can-stock but did a poor job of removing heavy ferrous metal objects and wire.

(4) A new "orange peel" design crane grapple of lighter weight and larger capacity than the original grapple was installed at the RDF storage pit. A single unit was purchased initially for test purposes.

(5) The RDF surge bin discharge belt conveyors were replaced with inclined vibrating conveyors.

(6) Procedures were instituted to burn RDF or coal separately in the boilers, but not simultaneously.

(7) The grate drive assemblies were modified including incorporation of a high temperature grease bearing system.

(8) The entire ash system was removed and replaced as follows:

(a) Bottom ash—submerged drag chain conveyors were installed to quench the ash. These conveyors discharge onto a belt conveyor system which transfers the bottom ash to the ash storage area.

(b) Siftings—the siftings ash collection system was not modified during the program. The existing system consisted of bins located under the siftings hoppers which collected the material. The bins were conveyed to the ash storage area and dumped using fork lifts.

(c) Reinjection ash—the ash reinjection system was deactivated. The downcomer ash tubes were re-routed to a single collection point. The boiler hopper and economizer ash is conveyed via a dry drag conveyor to the quench basin where it is mixed with the bottom ash.

(d) Fly ash—fly ash is conveyed via one of two redundant dry drag conveyor systems to a separate fly ash conditioning building. The material is continuously conditioned and then discharged on a conveyor belt for transport to the ash storage area where it is mixed with the bottom ash.

(e) Ash storage—a reversible mixing discharge belt conveyor was installed to allow deposition of the ash in one of any one of three storage bins.

(b) Satellite Shredder Stations. The satellite shredder stations are presently undergoing a general rehabilitation program which includes enclosure of a 1000 ton storage area at each station. The existing cross belt magnetic separator systems are being refurbished to improve performance and magnetic head pulleys are being installed following the main magnetic separators. The design to accommodate explosions is being modified with the addition of explosion vents, blast walls and conveyor modifications as appropriate.

PLANT PERFORMANCE

Overall plant performance with respect to RDF consumption, coal consumption, and gross electricity generation is shown in Fig. 2 for the period from January 1984 through July 1987. This graph shows a gradually improving trend in performance over time with a major improvement occurring in April 1987 when the benefits of the modification program in terms of increased RDF throughput and decreased coal consumption were realized. RDF throughput for the months April through July 1987 averaged more than 1800 TPD, and on many days exceeded 2000 TPD. As a result of the increased ability of the boiler fuel feed systems, boilers and ash systems to handle the RDF fuel, the overall system in Columbus switched from being boiler system limited to being fuel supply limited. The consumption of coal gradually declined but was still used to some extent to offset boiler plant upsets or when electricity generation was required in excess of that which could be generated with RDF, usually as a result of the shortage of RDF.

The Division of Electricity for the City of Columbus supplies electricity to customers, primarily in the downtown area, with a total load of approximately 75 MW. This load is supplied with a combination of elec-

tricity generated at the power plant along with power which is purchased from surrounding utilities. The purchased power must be scheduled 45 days in advance of actual delivery and is scheduled on an hourly basis. This delivery of scheduled power cannot be modified. Therefore, if the plant is unable to meet the difference between the total load and power purchases, additional power must be purchased under an unscheduled power purchase arrangement which is extremely costly. Therefore, plant reliability and availability are extremely important. Beginning in 1986, the plant has met more than 99% of its obligations and thus is performing well in this regard. It is believed that this is due in large part to the redundancy of equipment in the plant along with the ability to burn coal when necessary.

Beginning in February 1987, the ratio of RDF consumed compared to total fuel has exceeded 90% on a weight basis, which was a major performance objective of the modification program. Further, although exact records have not been kept, it appears, based on a comparison of fuel burned to electricity generated, that the overall plant efficiency beginning in February 1987 has improved by 5% to 10%. As the major obstacles to plant performance have been remedied, a new set of problems have emerged, primarily due to the significantly higher consumption of RDF. The three major areas continuing to require substantial maintenance attention are the main plant vertical shredders, the overhead cranes at the storage pit, and the RDF fuel feed surge bins.

Following is a discussion of the performance of individual plant components and an evaluation of the success of the various elements of the modifications program. As a result of the modifications program, plant performance has improved to the extent that a better assessment of the individual plant components can be made based on operating conditions more closely resembling what is expected to be an eventual normal operating mode of consumption of about 2000 TPD of RDF.

Satellite Plants

In mid-1986 the operation of the three satellite shredder stations was taken over by the Division of Electricity from another division of the Columbus City Government. This was done to allow closer coordination and integration of the satellite stations with operation of the power plant. The three plants are nearly identical, each consisting of a tipping area with a pan conveyor feeding a single horizontal shredder nominally rated at 60 TPH. The shredder discharges

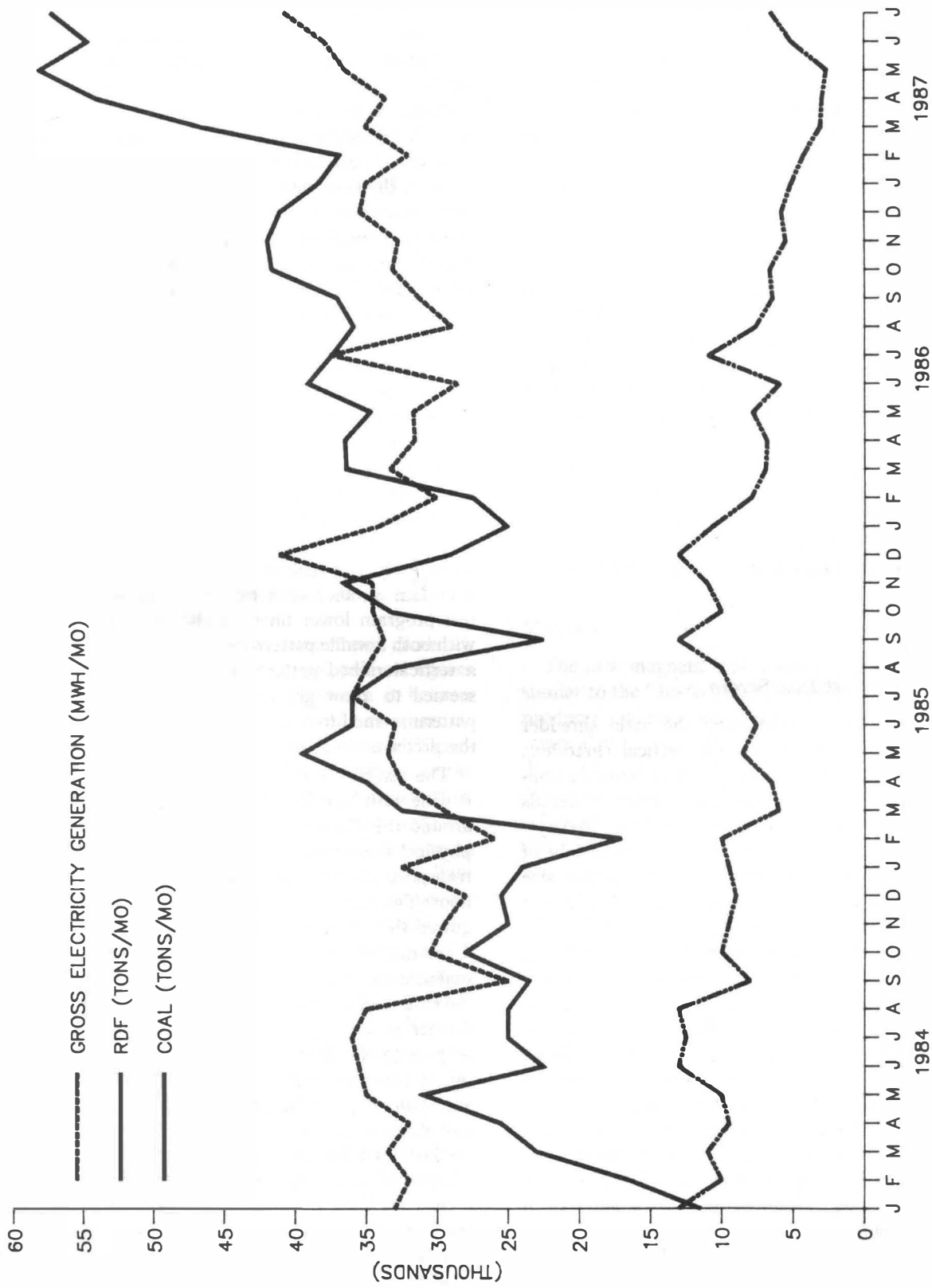


FIG. 2 PLANT PERFORMANCE, CITY OF COLUMBUS

onto a conveyor belt which passes under cross belt magnetic separator after which the material is deposited into a ram feeder which is used to load material into a transfer trailer for delivery to the main plant RDF storage pit. A modifications program has been initiated for the satellite plants in order to provide covered storage for 1000 tons of solid waste. Other modifications include additional explosion venting and prevention as well as minor refurbishing of certain parts of the plant.

Under actual operating conditions, the satellite plants have produced an average of 52 TPH of RDF or about 600 TPD per station. Based on extensive operating experience, it is known that the RDF produced by the satellite plants is satisfactory in terms of particle size and ferrous content for use in the main plant boiler facility. The satellite shredder stations are operated two 8-hr shifts per day on a five or six day basis depending on the need for RDF. On a combined basis, the satellite stations produce approximately 50% of the RDF consumed by the boiler plant. The Division of Electricity personnel have continued with the practice employed by the former operator of hard facing all of the hammers each night during the maintenance shift.

Main Plant

Shredders and Test Disc Screen

Early during the operation of the main shredder plant, it became evident that the vertical shredders, when operated with the recommended hammer configuration, were prone to producing oversized materials which were causing difficulties with the fuel feed system. It did not appear that the percent by weight of material greater than the 3-in. nominal particle size exceeded the contract limit, but rather that some of the plus 3-in. fraction was greatly oversized. This problem tended to increase as the shredder hammers would wear during the course of processing the solid waste. It was decided that a screening device should be tested to see if the screen, in combination with the vertical mill, would produce the quantity of material required with tighter control on the maximum particle size of material produced. As an interim measure, prior to installation of the screen, the hammer pattern was modified to reduce the particle size from the vertical shredders. However, in order to control the top-size of the material, the greater percentage of solid waste was over-shredded, resulting in an average particle size which was smaller than desired. In addition, the shredder throughput was reduced to between 35 and 40

TPH. A number of screening devices were investigated and it was determined that, given the physical space limitations in the RDF preparation area, the only practical choice was a disc screen. It was decided that a single disc screen and necessary conveyors should be acquired to test the concept. While it was recognized that the shredder and disc screen must be viewed as a system, it was necessary to first perform additional tests on the shredder by itself in order to optimize its performance for use with the disc screen. Such tests were performed over a four month period which resulted in a combination of hammers and knife blades being used. The three parameters used in optimizing the configuration were throughput, particle size and hammer/knife blade change interval. The optimization program resulted in a configuration that allowed an average throughput of 62 TPH. While a considerable amount of sample screening was done, in general the main measure of acceptable particle size was its effect on downstream fuel feed equipment. The selected configuration produced very acceptable fuel during the early hours of operation after changing hammers/knife blades, but it was necessary to watch the particle size closely as it tended to deteriorate all at once after a certain number of hours of operation. During the test program lower liners in the shredder were tried with both a waffle pattern (as originally furnished) and a vertical ribbed pattern. The vertical ribbed pattern seemed to allow greater throughput, but the waffle pattern seemed to produce more consistent fuel and is the preferred liner by plant personnel.

The test disc screen purchased was 26 ft long by 6 ft wide with 26 rolls. Chute and conveyor work in and around the disc screen was less than optimum due to physical space limitations. Conveyors were installed to transport the oversize material back to the tipping floor. The performance criteria for the disc screen required that the disc screen produce 60 TPH of minus 4 in. material (with a maximum of 2% plus 4 in. material contamination in the undersize) when receiving shredded material of 90% or more minus 4 in. The further requirement was that the disc screen remove or pass to the undersize fraction at least 90% of the minus four inch material contained in the feed. An approximate material balance using these performance guidelines required that the shredder produce about 74 TPH of RDF for delivery to the disc screen after removal of the ferrous material. The disc screen would deliver 60 TPH of minus 4 in. material to the RDF transfer conveyor with a maximum contamination of 2% plus 4 in. The screen would return about 14 TPH of material to the tipping floor with about half of that

amount being oversize with the remainder actually passing a 4-in. screen. Approximately 30 test runs were made with the shredder disc screen system and operation. The summary of the results is as follows:

(a) A major difficulty was experienced in loading the shredder with sufficient RDF to provide the quantity of material as required by the material balance noted above. Only about 10% of the tests were run at shredder throughput rates in excess of 70 TPH.

(b) Based on screening results, the shredder was able to produce 90% minus 4-in. particle size in about two-thirds of the tests. However, the great majority of these tests were run with throughput rates below the 74 + TPH required to achieve the 60 TPH net output from the disc screen.

(c) The disc screen produced RDF with an average oversize component of 2% to 4%. Rags and other large objects were virtually eliminated and the RDF product was considered to be excellent fuel by the power plant personnel.

(d) Wrapping of the disc screen rolls was very minor and was not considered to be an undue maintenance problem by plant personnel. This is probably due in part to a limitation in disc screen spacing recommended by the manufacturer which was intended to limit the wrapping problem.

(e) The shredder disc screen combination came relatively close to meeting the material balance figures noted above on two occasions. However, it became apparent that a disc screen acts not only as a particle size separator but also as a density separator. Therefore, the heavy materials passed readily through the disc screen while the lighter materials tended to float along the top of the bed and returned to the oversize fraction. Therefore, the material returned to the tipping floor was of very low density consisting of very light paper and plastic and to the casual observer appeared to be about equal in quantity to the material being delivered from the disc screen as fuel. The material returned to the tipping floor was about half plus 4-in. material and half minus 4-in. material. The material was difficult to handle due to its low density. Various attempts were made to reintroduce the oversize fraction onto the top of the material being fed to the shredder in-feed. This proved unsatisfactory as the overall shredder capacity decreased. In another case the oversize material was shredded in the south shredder by itself. The shredder was only able to process about 20 TPH due to the low density of the material. Both of these arrangements were deemed to be unsatisfactory to the operating personnel.

(f) Both the shredder and disc screen were observed to be very sensitive to the type of solid waste being

processed. Both the shredder and disc screen performed better when processing residential waste and poorer when processing commercial/light industrial waste. It was observed by plant personnel that the commercial/light industrial waste was processed more easily by the satellite shredder stations than by the main plant shredder station. The reason for these operating characteristics are not known, but it appears the vertical shredders have difficulty in processing material with a low density.

In summary, the combination of difficulties in reaching the desired throughput with the shredder/disc screen combination, along with the large volume of low density material returned to the tipping floor, made this arrangement undesirable from an operating standpoint given the need to produce large quantities of RDF for the modified boiler plant. Further, plant records indicate that the operating and maintenance costs at the main shredder plant significantly exceed those experienced at the satellite shredder stations. Additional testing is planned to determine if satisfactory performance can be obtained. If not, consideration will be given to replacing the shredder/disc screen combination with a horizontal shredder.

Magnets

The new magnets, which were in-line belt magnets similar to the "hockey stick" magnet in configuration, produced an immediate and major improvement in removal of ferrous materials. Data collected during the disc screen tests indicates that the new magnets removed about 50% more material by weight for a given throughput than was the case with the original magnets. The new magnets were able to pick up large, heavy ferrous items as well as wire in addition to the materials removed by the original magnets. The improved removal of ferrous materials resulted in reduced problems with the fuel feed system and boiler grate systems. One problem noted was that the increased removal of ferrous materials, and in particular wire, resulted in the entrapment of additional tramp material in the ferrous fraction which made the ferrous material less desirable for sale as a recycled material.

Cranes

Refuse deposited in the RDF storage pit must be retrieved and deposited in the RDF fuel feed bins with one of two bridge cranes. The capacity and duty cycle for the cranes was such that at RDF throughputs in the range of 2000 TPD, both cranes were required and were pushed to their limit, and represented a critical

path in the plant throughput rate unless RDF was delivered directly to the bins via the transfer conveyor from the RDF preparation area. The nominal capacity of each crane, which was equipped with a clam shell type bucket, was 1.5–1.7 tons per grab. A crane bucket with a larger capacity was desired, but in order to accommodate a greater RDF capacity, the weight of the grapple had to be reduced so as not to exceed the capacity of the bridge assembly. This was done using an orange peel type crane with a capacity of approximately 2.5 tons. The new grapple was viewed to be a substantial improvement over the original grapple and a second grapple of the same design was ordered. While this reduced the duty cycle on the cranes, the cranes continue to be troublesome. In particular, the control system has been unreliable and “shorts” have occurred in the festoon cable assembly. Given the size and configuration of the pit in comparison to the location of the RDF fuel feed bins, the demands placed on the cranes in Columbus are very severe.

RDF Surge Bins

The RDF surge bins installed during the original construction are still in use and continue to be a source of high maintenance requirements and significant downtime. The bins perform reasonably well when the horizontal augers are in new condition. However, performance deteriorates as the auger flights wear down. Some wrapping and ragging has been experienced with the vertical augers as the throughput has been increased on the vertical shredders. Once the auger flights wear down, the bins are more subject to bridging and the fuel feed to the boilers, which is controlled by the horizontal augers, becomes more erratic. This results in wider load swings with the boilers. Plant personnel are investigating alternative bin arrangements and may try a different design at some point in the future to see if surge bin performance can be improved.

Fuel Feed Vibrating Conveyors

Each of the six boilers has been equipped with two vibrating conveyors. This step followed a successful test program on one boiler on which the vibrating conveyors were installed. The conveyors on the remaining five boilers represent a refinement of the initial installation based on the results of the test program. The conveyors are inclined upward at seven degrees, have a 1½-in. stroke and 30 deg. angle of attack. The vibrators are both counterbalanced and isolated due to their installation in an existing structure, which was not designed for a large vibrating load. The conveyors

have performed nearly flawlessly since installation, providing a reliable and even flow of RDF to the boilers.

Fuel Chutes

The chutes between the vibrating conveyors and the boiler have been a source of periodic pluggages, which are believed to be the combined result of undersized chutes coupled with the high wear rate due to the increased RDF consumption at the plant. The RDF leaving the vibrating conveyors has best been described as equivalent to a waterfall into the chute which tends to follow a consistent path down into the boiler. The impact area, therefore, wears out quickly. Once holes occur in the liner plate due to the wear, the chutes tend to plug frequently. It is noted that pluggages occur most frequently during the spring and early summer when the RDF has the highest moisture content.

Boilers

Each boiler in operation is currently consuming 400–500 tons per day of RDF. Four or five boilers are on-line at any given time with the remaining boilers down for maintenance. Steam outlet conditions have been modified slightly with the pressure set at 700 psig and the superheat temperature at 700°F. Plant operators prefer to operate the boilers at 125,000–150,000 lb/hr steam flow rate as opposed to the 165,000 lb/hr nameplate rating. No significant slagging has occurred in these boilers indicating that RDF can be burned without removal of glass and grit and slagging can still be avoided. The boilers are inspected periodically, including measurement of tube thicknesses in critical areas. The loss of waterwall tube metal thickness on the sidewalls described in previous reports has been reduced significantly since the reinjection ash systems have been removed. While it can be said that this sidewall loss has been greatly reduced, measurements to date have given conflicting results as to whether the loss has been virtually eliminated or just greatly slowed down. Additional tube measurements are scheduled until the answer to this question can be determined for sure. Superheater tube loss has been negligible over the life of the project, although measurements are still periodically made. The installation of the vibrating fuel feed conveyors which evened out the flow of fuel to the boilers has all but eliminated the furnace pressure swings which were a problem during the early operation of the boilers. Additionally, the more even fuel feed has resulted in a much more even fuel bed, with very little piling, which has allowed the operators to

slow down the grate speed and operate with a thicker fuel bed. This reduction in grate speed appears to be resulting in longer grate life.

Ash System

The new ash system has performed up to expectations after the normal compliment of startup problems. Boiler shutdowns or curtailment of RDF firing due to ash system problems have been virtually eliminated. Thus, the ash system has probably made the greatest single contribution to improved performance of the plant. The installation of the new ash system represented a special set of construction problems in that the old system was removed and the new system installed without reducing plant RDF throughput. The new system employs rugged mechanical system components with slow operating speeds. Drag conveyor speeds for both the submerged drag chain conveyors and dry drag conveyors were set in the 5–10 ft/min range. Conveyor belts were sized at several times the width that would be selected based on the standard CEMA calculation procedure. Problems were experienced initially with incomplete cleaning of the conveyor belts at the head pulleys on the bottom ash conveyors. This resulted in a considerable amount of ash deposition underneath the return side of the conveyor belts, which in turn resulted in extraordinary labor costs to keep the area clean. After some testing, it was determined that an air blower system in combination with a multiple blade wiper system provided a satisfactory means of keeping the belts clean.

The fly ash is transported outside the original boiler house via dry drag conveyors to a special building addition where the conditioning takes place. It was originally planned to convey the dry fly ash to a silo where it could be stored and then conditioned on an intermittent basis. However, space and geometry limitations prevented the utilization of a silo. Therefore, a new system was conceived which conditions the ash

continuously on a semi-automatic basis. The system consists of a surge bin mounted on load cells. The load cells indicate whether the level of fly ash in the surge bin is increasing or decreasing. Based on this signal, the speed of the ash conditioner is either increased or decreased in order to maintain the ash in the surge bin at a constant level. Water is fed to the conditioner at a flow rate which is compatible with the ash flow rate. High and low level alarms are included on the surge bin for backup purposes. Three individual ash conditioning systems are provided to serve the two redundant dry drag systems conveying the fly ash. The overall strategy has proved to be remarkably reliable with a single conditioning unit being operated for as long as one month at a time.

CONCLUSIONS

The Columbus Project has made great strides toward meeting the goals originally set for the plant. Resolution of the major problem areas has allowed RDF consumption at rates that have caused secondary problems to surface which will also require resolution. However, recent operating results indicate that the Columbus Project will be able to meet or exceed the original goals as time goes on.

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