BALTIMORE

A LESSON IN RESOURCE RECOVERY

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BALTIMORE: A LESSON IN RESOURCE RECOVERY

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INTRODUCTION

Among the prime efforts to demonstrate state-of-the-art technology in resource recovery from mixed municipal solid waste was the Baltimore Landgard project.§ This project, which involved the present municipal waste disposal plant at Baltimore, Maryland, was conducted jointly by four agencies: the City of Baltimore, the U.S. Environmental Protection Agency, Maryland Environmental Service, and Monsanto EnviroChem.

The Baltimore plant was designed and built by Monsanto EnviroChem to thermally process (pyrolyze) 1,000 tons (907 Mg) per day of mixed municipal solid waste and to recover energy (in the form of steam) magnetic metals, glassy aggregate, and char at a cost of about $5.00 per ton ($5.26/Mg). Although the plant has not functioned completely as designed, its operational history to date provides information for the advancement of resource recovery technology.

The plant had processed approximately 125,000 tons (113,000 Mg) of refuse from the startup in January 1974 to February 1978, when the plant was shut down for the major modifications which will be discussed later.

ORIGINAL PROCESS DESCRIPTION

Although the Baltimore Landgard® facility is currently inoperative and undergoing major modifications, the tense of the following description is the historical present to portray the original plant (Figure 1) more vividly. City packer trucks entering the plant are weighed on a truck scale to determine the amount of refuse entering the plant. The city trucks then discharge

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§ Mention of commercial systems or products does not imply endorsement by the U.S. Government.

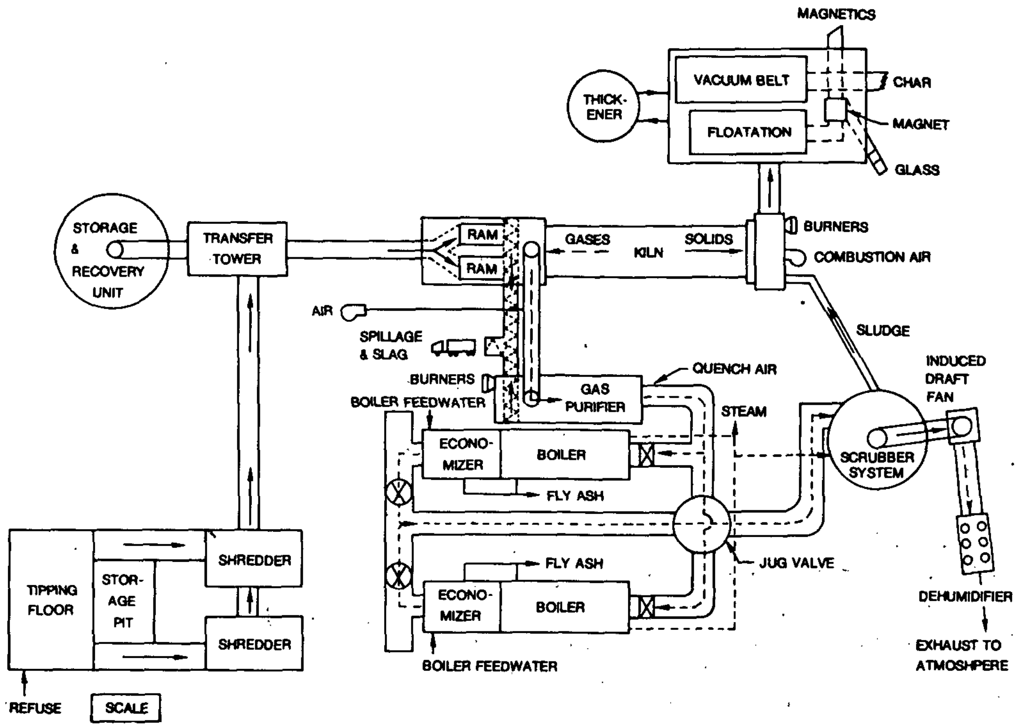

Figure 1. Process flow diagram (as originally constructed).

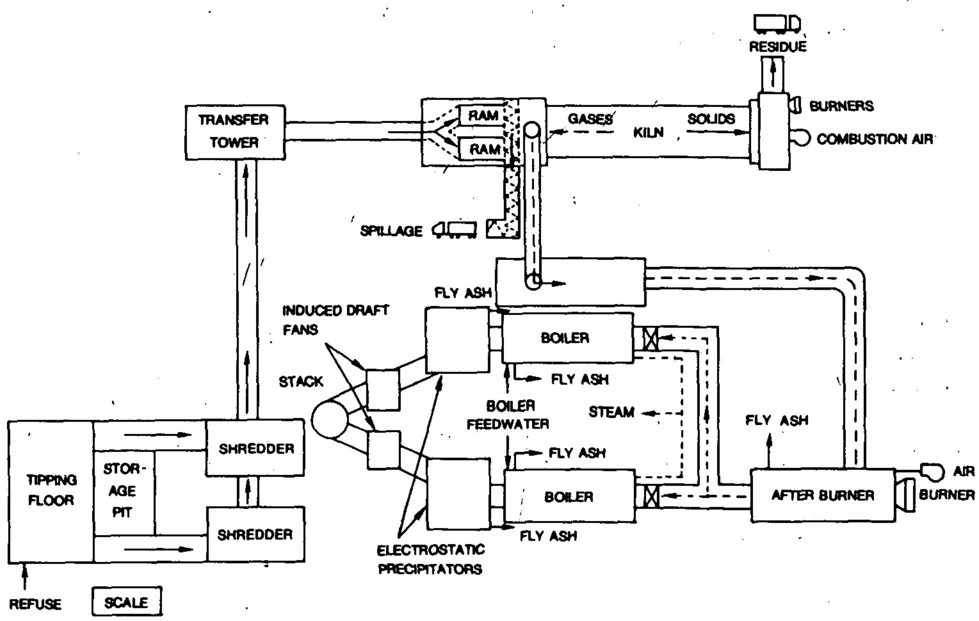

Figure 2. Process flow diagram (after modifications).

the refuse into a storage pit where it is stored until it can be fed at a controlled rate to the processing areas. The first of these areas is the shredding area, where there are two shredders in parallel refuse lines. The shredded refuse, discharged from either or both of the shredders, is collected and conveyed to a transfer tower. Within the transfer tower, the magnetic metals can be removed from the solid waste stream. The remaining solid waste is then discharged to either the storage and recovery unit or directly to a kiln feed conveyor. If the shredded refuse is discharged to the storage and recovery unit, it is stored, recovered, and discharged at a controlled rate to the kiln feed conveyor.

The kiln feed conveyor discharges to two ram feeders, which extrude the refuse through stainless steel tubes into the kiln. As the refuse tumbles down the inclined kiln, it is dried, volatilized, and partially combusted before being discharged into a water quench bath for removal by a drag conveyor. The residue removed by the drag conveyor is discharged into a flotation unit for separation and subsequent recovery of the various components in the residue. The light char floats within the unit and flows over a weir to a thickener. After the char settles in the thickener, it is pumped to a vacuum belt filter where it is further dewatered before its final disposition.

The portion of the residue which sinks in the flotation unit is then discharged to a flat rubber belt conveyor where the magnetic metals are removed by a magnetic belt separator for sale as scrap. The remaining glassy aggregate is then conveyed to a storage pile for use in asphalt road construction.

Fuel oil burners, which provide supplemental heat, and combustion air fans are both located at the discharge end of the kiln to provide a flow of hot gases and combustion air countercurrent to the refuse flow. The kiln-off gases exit the kiln at the feed end and proceed through a crossover duct where air is added to complete the combustion of the kiln-off gases within the gas purifier. As the gases travel cyclonically through the gas purifier, molten particulate is thrown to the walls of the gas purifier and flows to a slag tap hole at the bottom of the gas purifier near the crossover duct inlet. The slag falls through the slag tap hole into a water quench and frits into fine slag particles. The slag is then removed from the water quench by a screw conveyor which discharges it to a truck for landfill disposal.

Quench air is added to the gas purifier exit gases to cool the gases below the ash fusion temperature. The gases then flow through two parallel waste heat boiler/economizer assemblies and then to a wet gas scrubber. The gases exiting the gas scrubber then flow to an induced draft fan which produces sufficient suction to draw the gases through the entire system and finally discharges the gases through a dehumidifier to the atmosphere.

PLANT DEVELOPMENTS AND CHANGES

Since startup, the plant had been plagued with equipment malfunctions and shutdowns. In addition, it was not able to meet Maryland particulate emissions standards. On February 1, 1977, Monsanto EnviroChem withdrew from the project and recommended that the city convert the plant into a conventional incinerator. However, the city believed that the system had sufficient technical merit to warrant further investment to make the system more reliable. The future plant configuration, after completion of the city's modifications, is shown in Figure 2. Because of its severe equipment wear and refuse retrieval difficulties, the use of the storage and recovery unit will be discontinued. The residue separation area will be removed because of its questionable economics and the many modifications required to make it functional. The original slagging gas purifier will be used as a duct, and a new nonslagging gas purifier will serve as the afterburner. The wet scrubber, induced draft fan, and dehumidifier will be replaced with two electrostatic precipitators, two new induced draft fans, and a stack.

PLANT EXPERIENCE EXPLOITATION

While it is doubtful that the original process system at the Baltimore plant will be duplicated, the experience to date should be exploited in the design and operation of future resource recovery facilities.

Designing for Municipal Solid Waste Processing Equipment

Large variations in refuse compositions can seriously hamper the waste handling equipment, especially when commercial or industrial waste is not mixed before feeding it to the processing system. Such experience prompted the discontinuance of two direct dump chutes on the tipping floor of the Baltimore plant. Subsequently, all incoming waste was dumped onto the floor of the storage pit so that bulldozers could mix the waste before its delivery to the processing areas. With the variations in refuse composition thus reduced, the refuse could be handled more smoothly and efficiently.

Because of the varying size and irregular shape of the refuse, the chutes and troughs to collect and distribute the refuse were frequently bridged with refuse accumulations. Such bridging stressed the need for minimizing such passageways and for designing them with divergent or at least parallel sides.

That was critical to determine the bulk density of the refuse to be handled before designing for specific mass flow rates was highlighted during the plant operation. Since the refuse conveyors are rated for volumetric flow rates and the refuse at the Baltimore plant had bulk densities much lower than those designed for, the conveyors had considerable spillage when they were operated at capacity rates. In any event, the conveyors should always be designed for a worst case (minimum bulk density) condition.

As at other refuse processing facilities with similar equipment explosions within the two parallel shredders were potentially hazardous to personnel and damaging to the peripheral equipment as well as to the shredders themselves. However, the explosions were sufficiently minimized to prevent damage by venting the shredders to the atmosphere through a diverging chute and by installing an explosion suppression system.

Although shredders can be operated safely, their usage in this process may be questionable because of their high operating and maintenance costs. Moreover, the shredding pulverizes waste glass into a fine glassy grit, which severly abrades all moving equipment in the processing line. Consequently, it may be advisable to eliminate shredding and design the thermal processing equipment accordingly, or at least to trommel the refuse for the removal of metals, glass, and fines before shredding it.

The storage and recovery unit proved ineffective because of its numerous shutdowns and operational difficulties. After short storage periods (generally a week) the shredded refuse accumulation formed a densified mass intertwined with rags and wire. Frequently, the refuse was so compacted that it had to be removed manually. The refuse retrieval equipment consisted of chains of buckets which were pulled across the floor in a sweeping motion by a drive ring along the silo periphery so that the buckets would push the refuse into a recessed trough and conveyor at the floor centerline. When the equipment was used, the sweep speed had to be so increased to attain the required recovery rate that the bucket shoes and the floor wore excessively. On the basis of the wear data obtained at the Baltimore plant, the bucket wear shoes and the floor have a useful life of only 80 days at the design feed rate of 1000 tpd (907 Mgpd).

Among the more significant advancements in Resource Recovery Technology at the Baltimore plant was the development of the rotary pyrolysis kiln. The kiln, as the primary processing vessel, was unique to the Landgard process. Theoretically, the pyrolytic kiln has four advantages over the conventional incinerator: (1) lower temperatures to prevent the formation of metallic aerosols so that a gas scrubber rather than an electrostatic precipitator may be used to remove the particulate in the flue gas; (2) no underfire air to prevent the lofting of solid particles and therefore minimize the amount of particulate to be removed in the flue gas; (3) a lesser amount of excess air needed for combustion and therefore a greater energy recovery efficiency along with smaller-sized air pollution equipment; and (4) the use of refractory instead of grates which burn out more rapidly and therefore are more costly.

When the kiln for the Baltimore plant was designed from the prototype, the geometric scaling did not account for the aerodynamic and thermodynamic changes when going from the small-scale to the large-scale unit. As a consequence, the thermal processing at the Baltimore plant was not stable. The resulting instability caused the following sequence of phenomena: (a) a fireball, (b) temperatures 630°F (377°C) above the design level, and (c) refuse metals volatilizing into aerosols similar to those produced in incinerators. In addition, the high temperatures caused the refractory to spall and fall out rapidly.

To improve the control, stability, and reliability of the kiln process, an air bustle was installed in the kiln firehood to uniformly distribute the incoming combustion air across the firing end of the kiln and consequently to maintain a plug gas flow in the kiln. Also to reduce the fuel oil consumption by promoting autogenous combustion of the refuse, additional air was supplied to the kiln. Finally, the kiln refractory was replaced with the materials described in the design specifications, and better installation techniques were used.

After these modifications, the kiln operated satisfactorily with no further downtime due to refractory failure. However, the refuse metal volatilization in the kiln still continued and ultimately the gas scrubber will be replaced with an electrostatic precipitator.

Unrelated to the kiln process instability and high temperatures, the lack of underfire air proved of little advantage in reducing the particulate in the flue gas. For large amounts of particulate were introduced into the gas stream in (1) the kiln and (2) the crossover duct connecting the kiln-off gas outlet and the gas purifier. In the kiln, fines within the shredded refuse were entrained by the counter-current gas flow as they were lofted with the refuse fall from the feeder tubes and then with the refuse tumbling down the declined and rotating kiln. All refuse fines gathered by the dust collector system, extending from the shredders to the kiln feedhood, were discharged by the system fan into the crossover duct where they were entrained by gas flow.

While the wet scrubber was operating, the induced draft fan required frequent rebalancing (once every 2 weeks). The imbalancing was attributed to the build-up of wet solids on the fan rotor and to severe corrosion of the fan rotor. Severe corrosion also occurred in the scrubber, fan housing, and dehumidifier because of the large amounts of chlorine in the refuse.

Although the actual bulk densities were generally twice the design values, most of the frequent failures of the residue and slag conveyors were due to the large residue and slag masses. Occasionally, molten residue formed into balls as large as 6 feet (2 m) in diameter.

The entire residue separation system was operated for only a short time, because of its questionable economics and high manpower requirements.

Variation from the Design of the Prototype

Many of the operational deficiencies, malfunctions, and shutdowns in the Baltimore plant were due to equipment and processes that differed from those in the proven prototype system. For example, while the gas purifier in the Monsanto prototype was operated in a nonslagging mode, the gas purifier in the Baltimore plant slagged. During the demonstration, the frequent plugging of the slag tap hole at the bottom of the gas purifier caused extensive downtime.

Program Management

While the four agencies involved in the plant demonstration (the City of Baltimore, State of Maryland, Monsanto EnviroChem, and U.S. EPA) all worked toward the successful performance of the demonstration their particular interests, responsibilities, and orientation differed widely. In addition to their varying perspectives, any decision making had to be jointly approved by the City of Baltimore and Monsanto. Consequently, most of the plant shutdowns were prolonged because of the delays incurred while trying to reach mutually satisfying decisions. Further delays were due to city procurement procedures which required more than 2 weeks to process a purchase order. Moreover, since the city was not oriented to revenue-generating facilities, the city administration could not fully appreciate the requirements to increase the operating time for lower processing costs per ton of refuse.

SUMMARY OF OPERATION

The thermal efficiency of the plant was approximately 50 percent for an average refuse feed rate of 30 tph (454 kg/min). The capital outlay for the plant thus far has been $22 million. During the limited plant operation from the start-up in January 1974 to the shutdown for major modifications in February 1978, the annual operating and maintenance cost was $3 million, and the annual steam revenue was $1 million. The net operating cost based on historical data was $58.20 per ton ($64.10 per Mg) of refuse processed. However, if the annual throughput of 74,000 tons (67,000 Mg) could be substantially increased to the design level of 300,000 tons (270,000 Mg) by optimizing the plant operation, operating costs could be reduced to $7.10 per ton ($7.80 per Mg) of refuse processed.

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