Burning All Industrial Wastes in a Central Facility

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ABSTRACT

Manufacture of useful products in the modern age brings with it a flood of waste products from the various processes. This paper describes the present practice of burning industrial wastes and a new approach – a central facility – supervised by progressive waste management. The central facility incorporates four procedures, all of them automatic: waste conveying, waste feeding, waste firing, and ash removal.

INTRODUCTION

Engineers, in developing facilities to burn industrial wastes, have passed the stage at which special individual facilities were installed for each type of process waste.

Industry cannot afford the luxury of multiple installations, each staffed with individual operators, at various plant locations. The cost of installation and operation of individual facilities becomes a liability to factory managers trying to show a profit at the end of each year.

Engineers are challenged to design industrial waste-burning facilities that can be installed and operated at minimum cost at the same time that they are satisfying the pollution control standards enforced by public authorities.

Engineers foresee a new approach in solving the problem of burning a variety of wastes – a Central Facility to burn all the wastes – under the supervision of progressive waste management. They have to consider burning wastes in solid, liquid, gaseous, and sludge forms through a chemical process in a Central Facility. The chemical process should include pollution controls for waste materials that can be inert, toxic, flammable, highly reactive, acid, caustic, and so forth; and the recovery of useful products should be considered whenever commercially practical.

SCOPE OF WASTE BURNING

Burning of wastes is the reduction of waste materials, by combustion and heat, into a noncombustible residue that can be disposed of easily and hygienically so that it does not create a secondary nuisance. This requires that combustion take place (a) at temperatures high enough to burn and oxidize completely organic materials, that would decompose, and volatiles before release into the atmosphere; and (b) in facilities equipped for removal of pollutants – fly ash, odors, and toxic gases.

Industry is faced with stronger pollution-control standards and increased costs for the disposal of waste materials generated from the production of saleable products. The Central Facility approach seems to be a feasible solution.

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CENTRAL FACILITY PROCEDURE

Incorporating four automatic procedures, the Central Facility should burn:

1) Normal Refuse:
   - Solid waste paper
   - Wood
   - Garbage
   - Sweepings
2) Production Refuse:
   - Solid combustible wastes
   - Pasty combustible wastes
   - Liquid combustible wastes
   - Gaseous combustible wastes
3) Sludge:
   - Production sludge – combustible
   - Waste treatment sludge – combustible

The automatic procedures are waste conveying, waste feeding, waste firing, and ash removal.

PRESENT OPERATIONS

At the present, most solid wastes are hauled to private dumps – usually by outside contractors. In some plants, part of the waste is burned in a plant-operated incinerator and the remainder is carted to private dumps.

The cost of disposal is high and is increasing every year. Increasing cartage costs reflect the growing scarcity of suitable dump sites and strengthening governmental regulations of dump operations. The carting costs are reaching a point where they possibly may justify industrially owned and operated waste-burning facilities.

In the United States most waste burning, until recent years, had been in the province of municipal operation. These facilities have been designed to burn municipal waste having a low heating value without provision for heat recovery.

The incinerator manufacturers were very limited in know-how and experience in designing facilities to burn industrial wastes having more difficult and high heating values. There is even less experience with facilities to burn industrial wastes in heat-recovery units at efficiencies comparable with the burning of fossil fuels.

As industry enters the field of waste burning, equipment manufacturers will have to turn their research and development resources toward new concepts in the field of solid-waste disposal.

PROBLEMS FACING FURNACE DESIGNERS

Factual data is needed to inform and guide designers of future waste-burning installations.

Investigations into the operation of furnaces designed to burn industrial wastes show that lack of information about industrial process wastes has produced installations that did not conform to original design criteria; and furnaces designed from flimsy information, operated at high furnace temperatures, resulted in high maintenance costs, and produced many pollution problems for the owners.

The designers were not to blame for these shortcomings because they had to rely on the limited factual data available from municipal refuse experience in their specifications for industrial furnances. Thus they produced furnaces with unrealistic ratings.

NECESSITY OF WASTE ANALYSIS

Since the answer to any problem is determined by the amount of information available on the subject, the importance of factual data in the design of furnaces to burn industrial wastes, with or without heat-recovery units, is very obvious to the combustion engineer.

The necessity of waste analysis will become even more important as laws regarding air pollution are applied more forcefully and the high cost of installations is scrutinized more carefully. In the past, too much was done by the "by guess and by God" type of engineering, a luxury method we cannot afford today either in money or time.

Industry has done little to promote analysis of waste and testing of industrial waste-burning furnaces. The time has come to encourage industry to analyze its wastes and to test existing waste-burning installations, making data from such tests public through technical periodicals.

Laboratories specializing in fuel analysis can determine physical and chemical characteristics of waste. The findings should specify:

1) Water content – moisture, percent
2) Volatile matter, percent
3) Fixed carbon, hydrogen, percent
4) Ash content, percent
5) Heating value, Btu/lb
6) Corrosiveness – sulfur, chlorine, percent; also toxicity, odor, explosiveness
7) Ignition temperature, flash point, deg F
8) Ash-fusion temperature, deg F
9) Density, lb per cu ft

Table 1 summarizes the analysis of chemical industry wastes.

A comparison of industrial with municipal wastes, Fig. 1, shows that many industrial wastes include a large percentage of materials of high Btu

TABLE 1. FUEL ANALYSIS OF CHEMICAL WASTES

Sample No.	"As Recd" Heating BTU/lb.	Volatile %	Moisture %	Ash %	Flash Point COC°F	Fire Point COC°F	Sulphur %	Chlorine %	Dry Combustible %	Specific Gravity	Ash Fusion °F
1	14,466	69.21	30.72	0.07	–	420	0.29	0	–	0.7021	–
2	8,029	24.23	5.12	37.90	–	680	0.16	0	–	2.4132	2480
3	14,634	–	0.36	0.007	69	71	0.15	0.19	99.63	0.8577	–
4	16,014	–	–	0.003	68	76	0.24	0.13	99.99	0.7810	–
5	10,575	99.01	0.79	0.20	–	360	2.27	0	–	1.200	–
6	14,892	–	0.03	0.002	80	96	0.12	0.0	99.97	0.8714	–
7	14,567	–	0	0.14	50	50	0.17	2.64	99.86	0.9037	–
8	17,505	93.90	5.81	0.29	–	400	0.07	0	–	0.8904	–
9	11,949	–	0.02	0.05	81	92	0.12	13.39	99.93	1.0498	–
10	11,685	65.58	3.33	17.68	–	400	0.09	0	–	1.4498	2420
11	5,980	23.84	20.27	47.43	–	580	0.09	0	–	1.7705	2460
12	14,814	99.94	0	0.06	–	400	0.06	0	–	1.0821	–
13	15,933	63.45	36.5	0.05	–	190	0.17	0	–	1.0821	–
14	15,605	–	0.22	0	116	120	0.10	0	100	1.1803	–
15	13,151	92.11	1.15	0.26	–	440	0.44	0	–	1.2278	–
16	11,271	79.90	3.58	0.78	–	400	31.20	0	–	1.3405	1780
17	14,999*	–	36.0	11.76	–	–	–	0.12	2.24	1.1450	–
18	17,403	97.47	2.47	0.06	–	480	0.16	0	–	0.9731	–
19	15,751	97.82	0	2.18	–	540	0.33	0	–	0.9878	2380
20	11,844	78.65	10.45	10.90	–	440	0.04	0	–	1.1617	2800
21	9,122	67.63	32.09	0.28	–	440	0.31	0	–	1.0921	–
22	–	–	71.00	4.20	–	–	–	–	24.80	1.0544	–
23	17,079	99.98	0	0.02	–	420	0.02	0	–	1.3919	–
24	16,634	–	2.10	0.025	69	98	0.22	0.12	97.87	0.9237	–
25	13,895	91.00	5.11	3.89	–	740	0.08	0.	–	1.3847	2140
26	15,014	91.25	7.07	1.68	–	460	0.09	0	–	1.1195	1780
27	4,202	33.09	9.02	57.89	–	760	0.41	0	–	1.9231	2140
28	9,080	99.42	0.20	0.38	–	540	0.04	0	–	1.3809	–
29	–	–	89.07	7.78	190	–	–	–	3.15	1.0826	–
30	15,250	99.07	0.73	0.20	–	280	0.03	0	–	1.2348	–

NOTE: *Heating Value "Dry Basis"

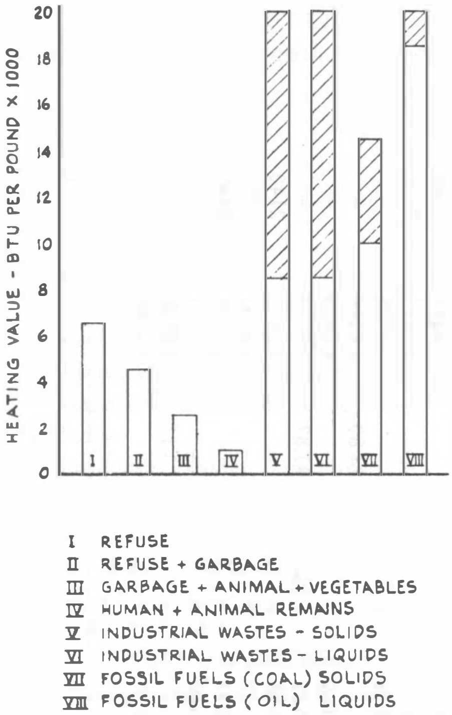

FIG. 1 HEATING VALUES OF FOSSIL FUELS COMPARED TO THOSE OF WASTE FUELS

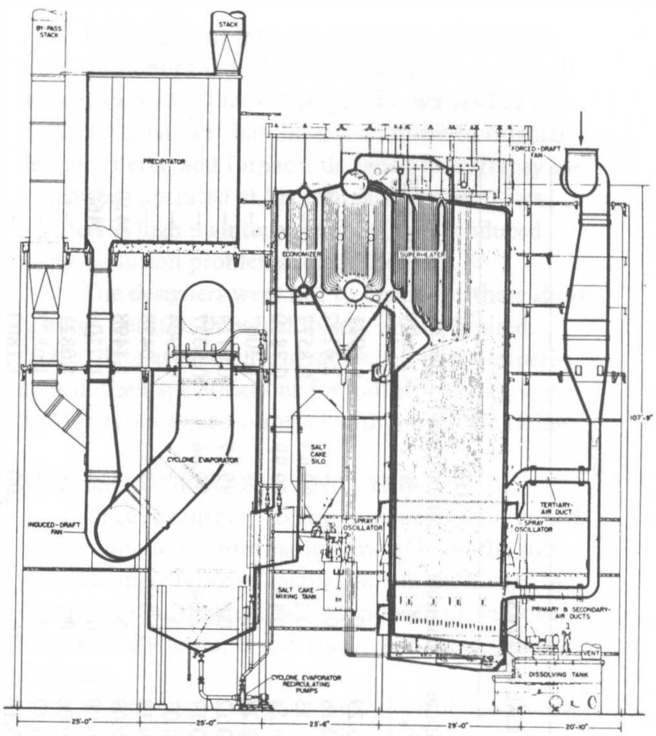

FIG. 2 BABCOCK & WILCOX BOILER WHICH BURNS BLACK LIQUOR FROM THE PULP AND PAPER INDUSTRY

content, close to that of average fossil fuels. The cost of analyses will be found very much worth the investment.

The author hopes that, in the near future, ASME will consider promulgating standards for test data necessary in the design of industrial waste-burning installations.

In addition to the analysis of industrial wastes by outside fuel laboratories, it is necessary to survey thoroughly the availability of plant wastes.

The survey usually is started with plant production management's initial task of defining sources, quantity, and nature of wastes requiring disposal. The survey should include:

1) Periodic weighing or measurement of volume.
2) Checking loads of waste hauled by private contractor to dumping area.
3) Availability of in-plant waste storage.

Investigation of data from the availability survey, along with anticipated plant wastes, current or expected in-plant pickup schedules, and present outside contractor transportation schedules must be made before determining an economical installation and furnace-burning schedule.

THERMAL RECOVERY

Waste heat available from burning of process-waste materials is being used to generate steam and reduce fuel costs in certain industries. Experience gained in this process by boiler manufacturers, when applied in the design of waste fuel-burning installations in other industrial fields, would tap a major portion of the neglected source of waste fuel available in the industrial field.

Heat Recovery

1) In the petroleum industry, the carbon monoxide gas generated from catalytic cracking of crude petroleum is being burned in a specially designed boiler with a pressurized furnace, and the installation has reduced air pollution and produced steam needed for process. Residues of tars and pitches from the oil-refinery process are being successfully burned in boilers.

2) In the pulp and paper industry, large integrated mills use black liquor and bark to generate a large share of the steam consumed in the pulping industry, Fig. 2. (Black liquor, the fluid residue obtained from the pulping process, has a low heating value of 4300 Btu/lb as fired with a high moisture of 50 percent.) In addition, inorganic chemicals present

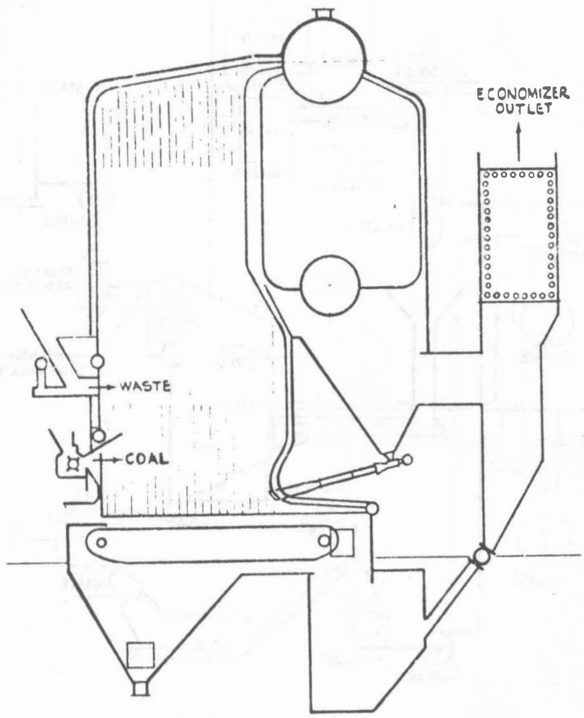

FIG. 3 RILEY STOKER BOILER WHICH BURNS COAL AND REFUSE

in the black liquor are recoverd. Bark available from the pulping industry has an average of 8500 Btu/lb on a dry basis and contains about 50 percent moisture. Today, boilers are designed to burn bark alone or in combination with other fuels.

3) In the metal industry, heat available in the waste gases has been recovered with waste-heat boilers attached to steel or copper furnaces. Air pollution control has influenced designers to consider lowering the flue-gas temperatures leaving these furnaces in order to permit the replacement of wet scrubbers with dry gas cleaning equipment. The waste-heat boilers reduce the departing flue-gas temperature to 500-600 F, allowing use of precipitators with high efficiency in collecting polluted air. Blast open hearth, copper reverberating, annealing, and billet-heating furnaces today are equipped with waste-heat boilers that generate process steam.

4) In miscellaneous applications, the chemical industry has recovered waste heat from kilns; the food industry has boiler installations to burn corn cobs, peanut shells, rice hulls, spent coffee grounds, coconut shells, and cotton seed hulls, Fig. 3; and the furniture industry has boiler installations to burn sanding dust, chips, shavings, sawdust, and wood scrap.

Design of Thermal Recovery Units

Waste fuels are similar in characteristics to fossil fuels in that they vary and require special design characteristics. Their heating values, ash content, moisture, and ash fusion vary considerably. (Fig. 1 shows a comparison of heating values.) Fuel-burning equipment and methods of introducing combustion air must provide intimate contact of the combustion air and the waste if the waste is to burn completely in the furnace. Solid, pasty, and liquid wastes each should be handled and charged into the furnace separately. Furnaces should be designed to provide complete combustion and to absorb some of the heat before it enters the convection boiler.

Waste-heat boilers will be equipped with, in addition to liquid-waste burners:

1) Fuel oil or natural gas burners to maintain steam loads.

2) Afterburners to burn the volatile gases completely before they leave the furnace.

3) Water-cooled furnaces requiring a minimum of excess air to achieve maximum boiler efficiency and air preheaters to increase overall boiler efficiency and improve boiler operation.

4) Mechanical dust collectors to catch the coarse particles and electric precipitators to remove the remaining fine particles.

5) Water scrubbers when flue gases are toxic.

6) Indicating and recording instruments, combustion safeguards, alarms, and indicating lights to give operators the means to proceed efficiently and safely.

CENTRAL FACILITY DESIGN

The Central Facility designer faces problems that need further investigation and new approaches.

A Central Facility

1) Has to be designed to incorporate the four automatic procedures mentioned earlier: waste conveying, waste feeding, waste firing, and ash removal.

2) Will require a specialized crew to operate the plant efficiently.

3) Will have to conform to Fire Underwriter's regulations and incorporate all the combustion safeguards necessary for a safe operation.

4) Will have to be designed for continuous burning through constant waste feeding in order to stabilize the conditions of burning – maintaining equilibrium and avoiding marked fluctuations in temperature, air, and gas flow; and continuous burning requires control of waste sizing.

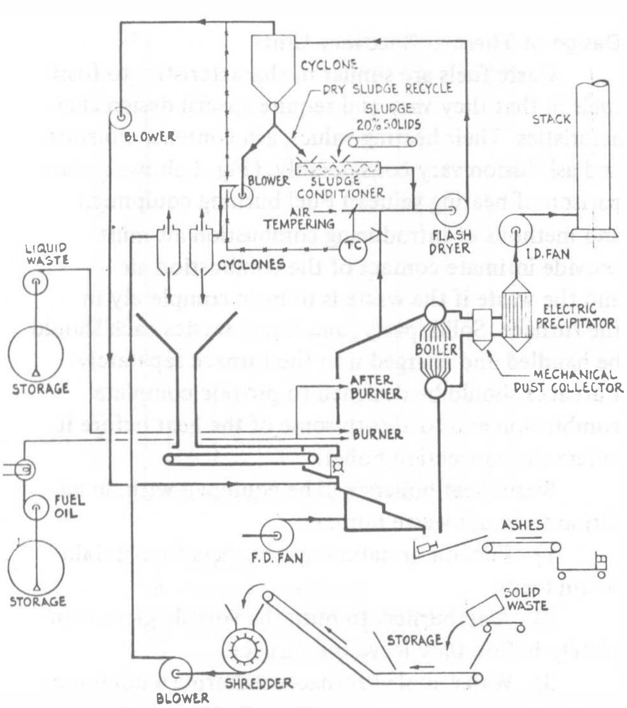

FIG. 4 FLOW DIAGRAM OF CENTRAL FACILITY TO BURN ALL WASTES WITH WASTE-HEAT FLASH DRYING FOR SLUDGE

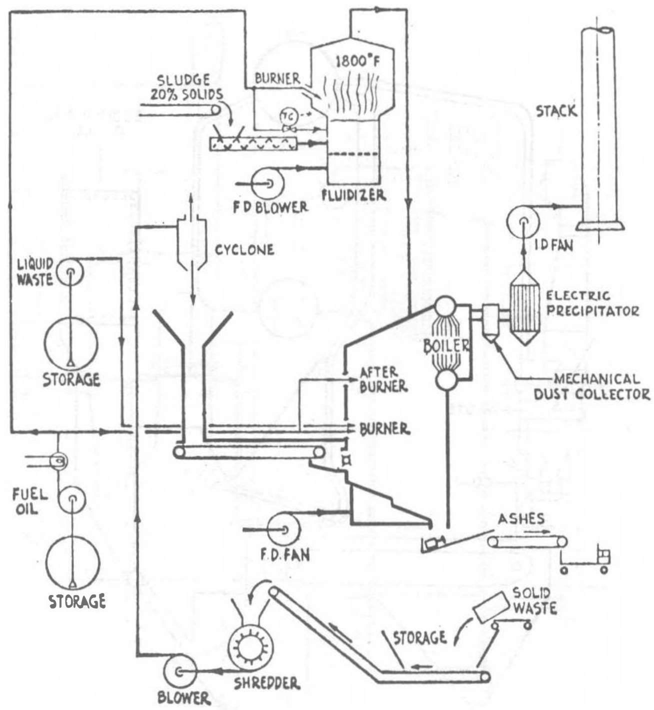

FIG. 5 FLOW DIAGRAM OF CENTRAL FACILITY TO BURN WASTE WITH SLUDGE BURNED IN FLUIDIZER

5) Will have to consider that dust entrainment is caused by high furnace velocities, which can be reduced considerably with water-cooled furnaces requiring a minimum of excess air.

The Central Facility "boiler" (heat-recovery unit) shall be designed to operate at saturated steam temperatures above the dew point of gases to decrease their corrosive action on the boiler tubes. Boiler tube spacing in the convection bank should be liberal to reduce velocities through the bank in order to avoid slag bridging and tube erosion. Air pollution control requires boiler exit gas temperatures below 600 F in order to permit the installation of standard mechanical dust collectors, electrical precipitators, and induced-draft fans. Toxic flue gas might require installation of wet scrubbers.

The Central Facility design in Fig. 4 burns all wastes in one furnace and uses waste heat to flash dry the sludge.

Fig. 5 is a Central Facility design to burn all wastes, except sludge, in one furnace. The flue gases from fluidized sludge combustion are introduced into the main furnace for heat recovery.

The Central Facility design in Fig. 6 also has one-furnace combustion for all wastes except sludge, which is burned in a rotary kiln; and, again as in Fig. 5, the flue gases from the sludge combustion chamber are introduced into the main furnace for heat recovery.

ECONOMIC JUSTIFICATION

An investigation of waste-burner installation costs shows that a large percentage of the cost is taken by engineering which requires many manhours, irrespective of the size of the job, since each installation is a specially tailored design.

Air pollution regulations require that each installation be equipped with the most modern particulate precipitators or water scrubbers so as to discharge flue gases carrying a minimum of air pollutants. Costs of cleaning flue gases do not decrease in direct proportion to the capacity but reach a minimum price tag below a certain capacity.

Costs will not be reduced until extensive research and development result in a waste-burning art applicable to the manufacture of package installations. Economic evaluation will show that a single diversified installation designed to handle a variety of plant wastes requires a minimum investment and has the lowest operating costs. The cost of installing and operating a large Central Facility to burn industrial wastes could be justified, whereas the cost of a small installation hardly could be on the basis of today's installation costs.

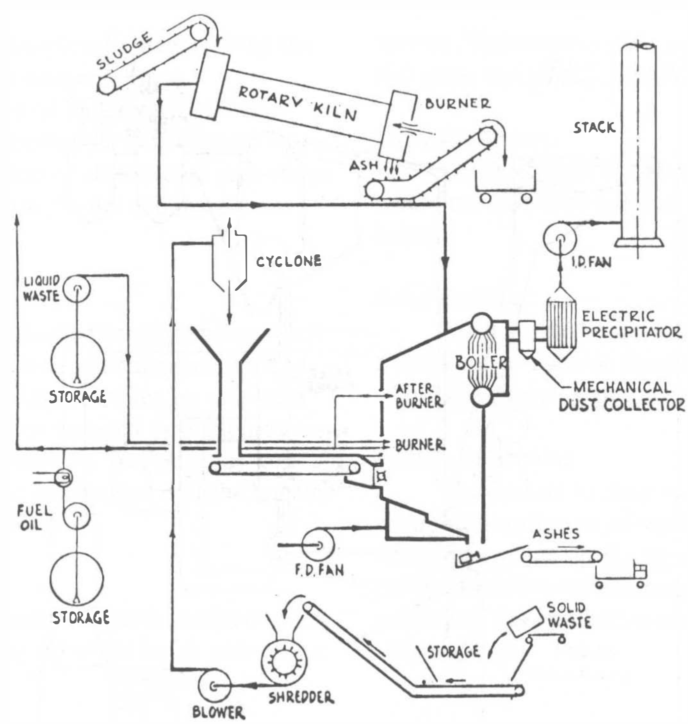

FIG. 6 FLOW DIAGRAM OF CENTRAL FACILITY TO BURN WASTES WITH SLUDGE BURNED IN ROTARY KILN

Economy dictates that industry consider installation of Central Facilities to burn multitudes of wastes on sites easily reached by industrial plants within a designated area. Such central installations (a) could serve a number of plants belonging to the same company within a certain area, (b) could be operated by a public utility to serve a municipal and industrial area, (c) could be operated by a municipality for burning municipal and industrial wastes and generating steam, for winter heating, and for summer air conditioning, within a commercial and industrial complex.

WASTE PREPARATION

Solid Wastes

Solid wastes will not be fed to the furnace in the varying sizes they are received from all over the lot but will be fed to a shredder which will produce a uniform size that can be conveyed to the furnace.

Liquid Wastes

Liquid-waste analysis will determine (a) whether or not certain categories can be unloaded and stored in a common tank and (b) how many storage tanks are necessary. A storage tank may have to be equipped with an agitator to provide a homogeneous mixture that can be pumped to a burner for final combustion in the furnace if preliminary investigation shows that certain liquids by themselves will not flow readily but, when mixed with other liquids containing solvents, will flow and then can be pumped for combustion in the furnace.

Sludge Handling

Sludge will vary with the type available from a particular operation – waste treatment or process sludge. Sludges that contain a high percentage of water from a waste-treatment operation and that can be readily pumped require an economic investigation of various available burning systems. One of the available systems is partial drying of the sludge before it is burned. Another of the systems is to burn sludge, without reducing the moisture, in a fluidized bed or rotary kiln and convey the flue gases to a waste-heat boiler for heat recovery.

WASTE AND ASH HANDLING

Solid Wastes

Solid wastes will be unloaded into an area that can provide adequate storage for a minimum period, depending upon local conditions. Equipment breakdown exigency might require an emergency storage

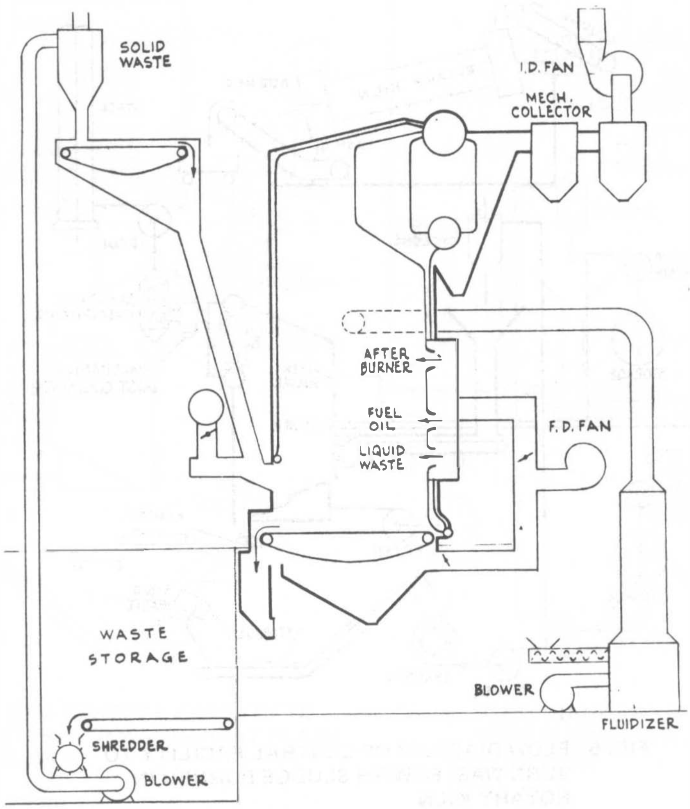

FIG. 7 FLOW DIAGRAM OF CENTRAL FACILITY TO BURN WASTES WITH SLUDGE BURNED IN AUXILIARY FLUIDIZER

area which, if its need arises, should be investigated. From storage, the wastes can be conveyed by belt to a shredder for processing to uniform size and then can be conveyed pneumatically to a cyclone for separation and automatic feeding, rotary or pneumatic, to the furnace.

Sludge

Dried sludge also will be conveyed to the solid-waste bunker and fed to the main furnace; but wet sludge, from the waste-treatment plant or from process, which has not been predried will be conveyed to a fluidized furnace for combustion, and the resulting flue gases will be sent to the waste-heat boiler for heat recovery.

Liquid Wastes

Viscous liquid wastes will be pumped from a storage tank to a burner, atomized by air or steam, automatically fired into the Central Facility furnace. Liquid wastes requiring preheating will be pumped through temperature-controlled heaters before reaching the burner.

Ash Handling

Mechanical conveyor belting that will withstand abrasion and reasonable temperatures encountered in ash handling operates at low cost and requires low maintenance. Ash sluicing systems have been used considerably in boiler houses burning coal and such a system could be applied easily to waste-burning installations where metal objects are removed from the ashes.

POLLUTION CONTROLS

The passage of the 1967 Air Quality Act and the recommendation it received from President Lyndon B. Johnson emphasize the fact that air pollution control, a prime element in any new installation today, will have to be taken into consideration in any design which devolves from thorough analysis of wastes burned in a Central Facility.

OPERATION

The operation of a Central Facility, which will have to be patterned on that of public utilities, will be an automatic one with attendants ready to act if an emergency arises and a maintenace crew to keep the installation in good operating condition.

Fig. 7 shows a Central Facility with all functions automatically controlled for a continuous operation and with combustion of all wastes except sludge taking place in the furnace. Sludge is burned in an auxiliary fluidizer.

Waste Handling

Solid wastes are unloaded in a storage area, fed by belt to a hogger-shredder, and conveyed pneumatically into the furnace. Liquid wastes are unloaded into storage tanks and then pumped through heat exchangers to the furnace burners. Wet sludge is conveyed to the fluidizer for combustion and the hot flue gases go to the main furnace.

Heat Recovery

An afterburner would complete combustion of the flue gases before they enter the boiler convection section. The boiler convection surface would cool the flue gases and generate steam.

Pollution Control

The flue gases, on leaving the convection section, would be cleaned to meet air pollution control regulations.

Ash Handling

Ashes would be quenched and dumped either on a conveyor to a silo or directly on a truck for transfer to outside dumping grounds.

Economic Burning

The Central Facility seems to be the answer to economic burning of all wastes. Engineers will be devoting more time, in the years to come, toward improving installations and reducing costs so that the public will have pollution control at the lowest possible expense.