Note :

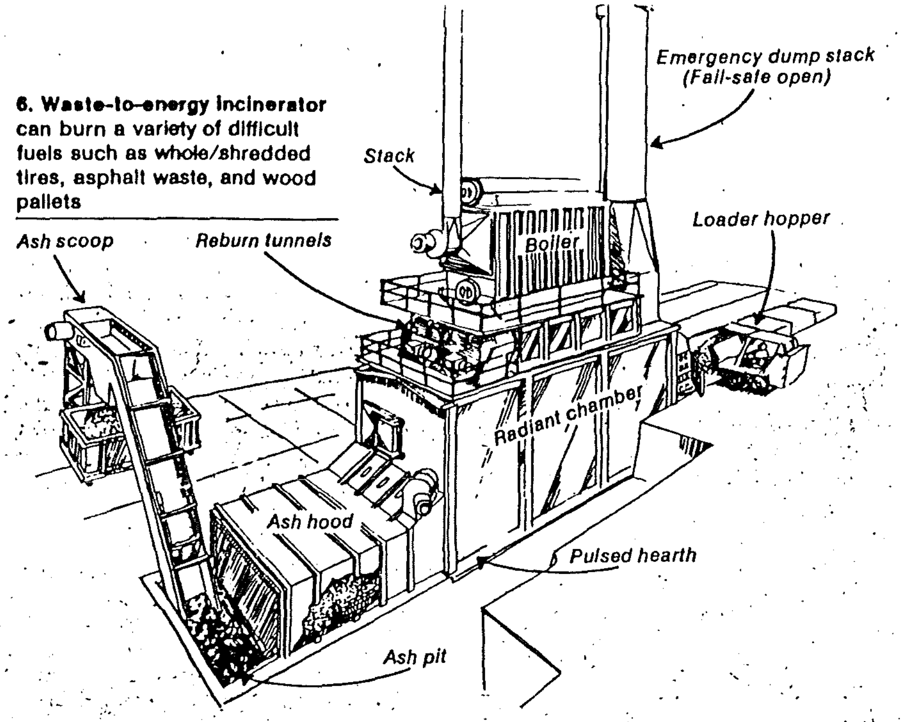
Through the efforts of the West Burl. Cit. Gr. (Sol. Waste Mgt. Comm.) the Region changed its long term plans

from purely landfill

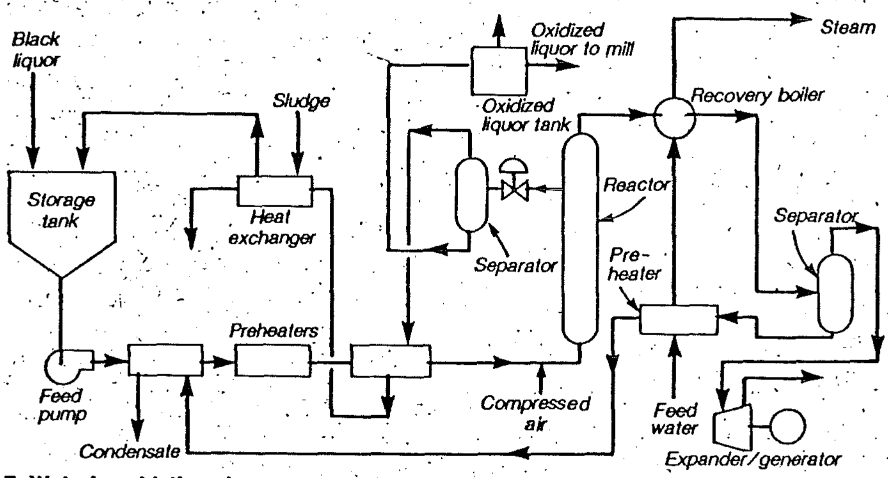
to
- max. EFW (heat producing steam, not fuel)
- max. recycling (Source Sep.n)
- Min. landfilling

The change fell back on a previous policy declaration that had been ignored to that point.

Mar. [illegible] '84 H. Koeplin



6. Waste-to-energy incinerator can burn a variety of difficult fuels such as whole/shredded tires, asphalt waste, and wood pallets



7. Wet-air-oxidation plant generates byproduct steam from a 12%-solids black-liquor stream from a pulp and paper mill. Reactor conditions are 600F and 3000 psig

Some wallboard manufacturers have cooperated in defining specifications for FGD-byproduct gypsum, but similar cooperation in deciding what the material is worth has not been seen to date, largely because the user realizes that the utility's only option is to dispose of it.

Putting wastes to use in the powerplant

Many wastes generated by industry and by institutions—traditionally disposed of in landfills or incinerated—have heating values that can be used in the powerplant. While the idea of recovering energy from waste products has always been appealing, applying it at full scale has often been difficult. It is true that many industries have been injecting solid-liquid-, and gaseous-waste streams into their boilers for years, but the waste usually represents only a small fraction of the total fuel input.

Combustion facilities dedicated to firing waste fuels have to be designed to accommodate a wide variation in fuel characteristics instead of the comfortable range associated with conventional fuels like coal, oil, and natural gas. And the reputation of firing waste fuels is less than stunning. Many techniques for burning them, which were developed in the US after the oil embargo, have demonstrated only average-to-dismal performance.

But industry is much further along on the learning curve. Engineers now have a greater appreciation for the design, operating, and maintenance complexities associated with recovering energy from waste fuels. Whole new processes and important components of existing systems—such as burners in conventional boilers and materials-handling equipment for refuse-fired boilers and incinerators—have been designed to handle the extremes in waste-fuel quality. Pyrolysis, gasification, and incineration processes, traditionally used only for destroying waste, have been commercialized for energy recovery as well.

Fluidized-bed combustion (FBC) is one technology that can handle a wider variety of fuels, and today, FBC boilers are largely commercial on the industrial scale. Many plants are operating worldwide that have been designed to burn rice hulls, cotton wastes, coal-washing tailings, woodwaste, refinery offgases, and municipal sludge (POWER special report, *Fluidized-bed boilers*, August 1982). Fluidized-bed technology is also available for gasification of wastes.

Wet air oxidation is an example of a process that has destroyed hazardous and nonhazardous wastes for years. It shows promise in the future for generating steam and possibly electricity.

Municipal solid waste

This abundant fuel is receiving much attention today as a potential fuel, and the technology for burning it has been extensively covered in previous POWER articles (Special report, *Power from waste*, February 1975; December 1982, p 77; April 1983, p 106).

Recently, EPRI has sponsored field tests with cofiring of refuse-derived fuel (RDF) and pulverized coal in utility boilers. Major drawbacks determined were increased accumulation of slag on boiler surfaces, overloading of bottom-ash-handling systems, and reduced boiler efficiency and generating capacity. To avoid these problems, ash, moisture, glass, and metal content of the RDF must be minimized. EPRI considers mass-burning technology to be commercially viable for electric-power generation, but classifies RDF technology as near-commercial. In general, EPRI suggests that using municipal solid waste is more attractive in dedicated boilers.

Burning tires—whole

Early incinerator designs typically emphasized complete burnout of the waste rather than efficient, clean combustion. That philosophy has changed. And the applicability of new designs extends well beyond ordinary municipal solid wastes. For example, scrap tires represent one of the least recognized disposal problems in this country. Each year, 180-million are scrapped; at 20 lb apiece, and with a net heating value of 15,000 Btu/lb, the energy-recovery potential is enormous. Exploiting this potential has been a problem, especially in feeding the tires either whole or shredded into an appropriate combustion chamber. The steel belts are difficult to remove in the bottom-ash-handling equipment, and the gumminess of rubber waste compounds makes maintenance difficult.

Nevertheless, one industrial plant is burning tires whole in an incinerator and generating 20,000 lb/hr of steam from them. Early favorable experience has induced the company to order a second unit for another plant site.

The design is something of a novelty (Fig 6). The feed system is a pulsed-hearth design—a suspended brick furnace floor in a step configuration with air jets along the steps. The hearth is intermittently pushed along the length of the radiant combustion chamber with air bags. This pulsing shuffles the waste in whole form through the system, and provides more efficient mixing of the fuel and air, limits the amount of tar-like substances on the floor, and reduces the potential for ash to slag boiler tubes.

The radiant chamber of this boiler has water-cooled walls to reduce the high amount of maintenance normally associated with refractory. The radiant section produces about 30% of the steam. Remaining combustibles are burned in reburn tunnels. After this recovery step, the combustion products pass through a convection section where the remaining steam output is produced.

This incinerator design makes it possible to recover energy from a variety of difficult-to-burn solid fuels. One unit at a refinery/roofing-products complex in Oklahoma burns asphalt scrap and will soon burn sulfuric acid sludge from lube-oil refining. Plant engineers at this site rejected rotary-combustor incineration because it requires a heavy investment in air-pollution-control devices. Rotary combustion requires high-velocity combustion air. Fluidized-bed incineration was also rejected because of the potential of molten asphalt to plug the vertical combustion-air jets.

Wet air oxidation

The idea of burning low-grade fuels and wastes in the aqueous phase—commonly called wet air oxidation (WAO) or wet combustion—is not new. Over 150 plants that use WAO have been in service for several years, mostly for processing sewage sludge. Today the technique is being adapted for conventional and waste-fuel firing to generate steam/electricity; it can also be used to generate CO_2 for the enhanced-oil-recovery industry.

In WAO, a solution or slurry of suspended organic substances is elevated to a high temperature and pressure in a closed vessel (Fig 7). The high pressure limits evaporation of the aqueous phase. Compressed air is bubbled through the liquid phase, and the O_2 reacts with the organic material. A family of related oxidation and hydrolysis reactions then take place. Depending on reactor conditions, a range of combustible products is created—final products are water and CO_2 if the reaction proceeds to completion.

All sulfur forms are converted to sulfates, and nitrogen is converted to ammonia; thus, SO_2 and NO_x emissions are negligible in the gaseous effluent. Developers believe that it may be the one combustion process that can be permitted in a pristine or nonattainment area, as defined by EPA.

In energy-recovery applications, the hot gas produced by the reaction is not burned directly, but the heat is transferred to boiler feedwater to produce saturated steam at up to 800 psig. If desired, the offgases can be expanded through a suitable turbine or reciprocating expander to generate electric power, but this feature has not been adequately demonstrated to date.

As long as the material can be injected into the reactor, the WAO process will oxidize it. There is one notable advantage of the process: The latent heat of the moisture in wastes, low-grade fuels, dilute sludges, and liquors can be recovered. Therefore, the combustion efficiency of the process does not suffer as much with high-moisture fuels, unlike other combustion methods.

Disadvantages of the process are high capital costs, high power consumption to run the compressors, inability to produce high-pressure, superheated steam for economical power production, and the possibility of having to scrub highly volatile compounds such as methanol and carbon monoxide from the effluent. The use of O_2 instead of air would allow for operation at a lower pressure, reducing the size and cost of much of the equipment.

Methane from landfills, sewage

Landfills and wastewater-treatment plants are potential sources of methane, which can be burned in conventional gas-fired boilers, gas turbines, and oil/gas engines with minor modifications. Equipment for methane recovery is being retrofitted to existing sites, and new treatment plants are being designed to use anaerobic processes, which can produce methane, instead of aerobic ones.

The amount of recoverable energy is often considerable. To illustrate: A sewage-treatment plant in California generates 14 MW of electric power and 28,000 lb/hr of process steam—enough to cover nearly 80% of the plant's power requirements. The digester gas has a heating value of 550 Btu/scf and is raised to 380 psig by reciprocating compressors before it is burned in gas tur-

Industry turns wastes into business opportunities

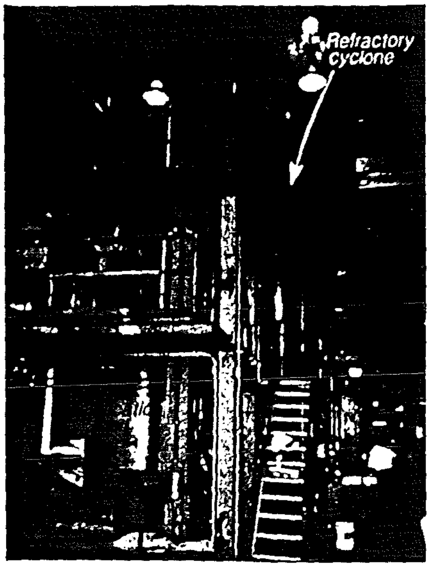
Many large chemical and petrochemical corporations have formed separate business divisions to find uses for waste streams—either their own or those of an outside firm. It is a natural development, since chemical companies have been characterizing waste streams and burning nonrecyclable materials in their boilers, furnaces, and kilns for years. Only recently have the programs been formalized, however.

Stauffer Chemical Co, Westport, Conn, has been burning waste organics as fuel in its industrial furnaces and kilns for eight years. The company now routinely collects bulk and drum quantities of medium-to-high-Btu industrial wastes from other companies that are compatible with what Stauffer defines as nonconventional fuels. These materials are blended in a controlled operation at one plant site in Tennessee. Blending is performed with adequate quality control.

One way Stauffer maintains quality control is to perform chemical and physical analyses of a company's waste stream at no cost. Then the material is classified as hazardous or nonhazardous and accepted or rejected from the reuse program.

Monsanto Chemical Intermediates Co, an operating unit of Monsanto Co, St. Louis, Mo, has a similar program which it calls "Coproduct utilization." The intent is to identify uses for waste streams either within the company or for sale to another firm. The first successful arrangement made was for the use of dibasic acid—formed in the manufacture of adipic acid—as a means to enhance FGD efficiency.

EPA has been conducting research on the effect of organic acids on wet-limestone FGD performance, and adipic acid is one that is deemed effective. Monsanto, in turn, subsequently ran tests with the assistance of EPA to determine if dibasic acid would serve as an inexpensive substitute. The results were positive, and indicated that dibasic acid use has other advantages as well, even though it is only 85% as effective as adipic. For one thing, dibasic acid is liquid—adipic is solid—making transport and storage easier.



8. Biomass gasification facility converts waste into high-grade fuel which is burned in existing oil/gas-fired boilers

bines. On Staten Island, NY, a 400-acre site developed by Brooklyn Union Gas Co. yields 10-million ft^3/day of gas. Here, the gas is treated to remove moisture, CO_2, and trace elements to make its heating value equivalent to that of natural gas. After treatment, it is piped to the utility's customers.

Anaerobic sludge-treatment processes have been developed that can also recover methane and that are net-energy producers, if the wastewater has a high chemical oxygen demand (COD). Some industries, such as chemical, petrochemical, pulp and paper, and food, have wastewater streams worth treating anaerobically. These processes are less energy intensive than conventional aerobic ones, because the aerators that supply the O_2 from air are eliminated, and they significantly reduce the amount of sludge destined for an environmentally controlled landfill.

Be aware that process monitoring and control is critical to successful anaerobic operation, because wastewater streams vary considerably in constituents and flow rate and industrial wastewater plants are subject to upsets or dumps when a particular processing unit goes awry. Also, if recovered methane is to be a significant portion of boiler fuel, the gas may require pretreatment. At least one commercial process is capable of 90% COD removal, but even this rate may not be enough for some high-strength industrial wastes, and an aerobic polishing step may be necessary.

Convert wastes first

In many instances, it is beneficial to convert hard-to-handle wastes into a more flexible form so that conventional equipment can be used to burn it. Many gasification, liquefaction, and pyrolysis processes have been developed for this purpose. But an alternative to actually converting the waste into a different phase is to compress it into fuel pellets.

There are a few companies around that produce and market fuel pellets or briquettes, which are made from many different solid and liquid wastes. These can be burned in conventional solid-fuel- and multi-fuel-capable boilers.

These companies claim that the shape and density of pellets allow them to be stored and transported in existing coal facilities with few modifications. In addition, some pelletizing methods completely separate all noncombustibles, leaving a fuel that burns cleanly at high temperatures. A particular advantage to pelletizing is that it makes difficult-to-handle wastes—like coal fines, sewage sludge, and waste solvent—easier to burn. Some claim that the product is actually superior to coal because it can be made freezeproof, dustproof, and leachproof, and contains no sulfur or chlorides.

Pelletizing involves using a binder to hold the solid particles together. Certain chemically inert liquids can serve as binders, but another approach is to use properties inherent to coal and hydrocarbons. Coal is olephilic and naturally attracts liquid hydrocarbons such as waste oils, solvents, and greases. The coated particles then adhere to each other, and the resulting beads can be formed into larger briquettes through simple mechanical processing. Ash and inorganic material do not naturally adhere to hydrocarbons and can be removed through a separation step.

Quality control is essential in pelletizing wastes into fuel. Certain plastics and other materials release toxic gases on combustion, and great care must be exercised in screening the wastes going into the fuel.

Pyrolysis is the thermal decomposition of matter with no oxidation. It is an endothermic reaction, requiring an outside source of fuel, but overall, it produces about four times as much energy as it consumes. In general, material undergoing pyrolysis releases vaporized organics which can be burned in an afterburner or condensed to produce a liquid fuel product.

Many pyrolysis processes, developed primarily for municipal solid waste in the last 10 years, have shown only average performance at best. A major problem is that combustion is sometimes incomplete and there may be a wide variety of toxic compounds available for release to atmosphere.

Today the technique is getting a second look and is being applied to other wastes, such as tires and waste plastics. One firm markets a small 500-lb/hr batch tire pyrolyzer.

A commercial facility in operation at a plastics-manufacturing plant in Texas pyrolyzes 17-million lb/yr of waste plastics into 2-million gal/yr of fuel oil with characteristics ranging between No. 2 and No. 6 fuel oils (POWER, September 1982, p 144). Tests indicate it can be burned directly in an oil-fired boiler without upgrading the product.

When a pyrolysis reactor is designed to produce fuel gas only, it is generally called a gasifier. The state of California recently started up a fluidized-bed-gasifier facility that uses biomass wastes to provide 50% of the energy requirement for some major office buildings in Sacramento. The unit (Fig 8) produces 50-million Btu/hr of low-Btu gas from a chamber in which sand and biomass materials are fluidized at 1500F. Conversion efficiency is 95%.

A fluidized bed will gasify wastes in drastically reduced residence times—two to five minutes, compared to two to five hours for conventional pyrolysis reactors. Operating temperatures are also lower, limiting the potential for slagging and ash fusion. The thermal capacity of the fluid, inert material, along with the tenfold increase in thermal and mass-transfer rates, allows this type of pyrolysis unit to handle high-ash, high-moisture wastes more easily than static pyrolysis units. ■

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