Incinerator Designed Specifically to Burn Waste Liquids and Sludges

D. P. BRIDGE
PPG Industries
Pittsburgh, Pennsylvania

J. D. HUMMELL, P.E.
Alden E. Stilson & Associates, Ltd.
Columbus, Ohio

ABSTRACT

The incinerators described were developed to dispose of waste liquids and sludges from paint and resin plants. The operation of two prototype designs demonstrated: (1) complete combustion without fluid atomization, (2) ability to burn organic liquids containing dissolved and suspended solids, (3) low noise level, (4) smoke-free stack effluent without the use of air pollution control equipment, (5) self-sustaining combustion after initial preheating, and (6) potential for heat recovery.

Since November 1970, the first operational and instrumented unit has been used to burn the organic waste liquids from a resin plant.

An operational unit of the second type has been designed to burn paint manufacturing wastes containing inorganic pigments. Performance data are expected to be available at the time of presentation of this paper.

INTRODUCTION

Because of the well known shortcomings of the common practice of dumping waste liquids in landfills, PPG Industries initiated a program to develop satisfactory disposal methods for the organic wastes from its coatings and resin plants. A study of equipment and processes available at the commencement of the program indicated that none of these could adequately meet all of the objectives required. Incinerators, with the potential of heat recovery, seemed most applicable provided they could be built to burn the variety of wastes at reasonable capital, operating, and maintenance costs. Therefore, a program was initiated to develop the incinerators for the specific purpose of burning the still sludges and defective batches from the company’s plants.

This paper describes the need for new incinerators, their design objectives, the nature of the waste liquids, the evaluation of the basic designs, the operation of two prototypes, the operational unit which is now being used to dispose of waste liquids at a resin plant, and the design of a unit planned to burn wastes from paint plants. Additional operating data are expected to be available for discussion at the time this paper is presented. Patent applications have been filed claiming the features of each type.

NEED FOR NEW INCINERATORS

The decision to develop new incinerator systems for disposing or organic waste liquids resulted from experience and study of disposal of these substances by landfilling and by burning in commercially available units. Neither of these techniques seemed adequate to handle the wastes from PPG’s plants for the reasons discussed below.

Landfilling

To date landfilling has been the primary method of disposing of liquid organic wastes because it is a low cost, easy method of disposal which requires little expertise. However, as ecology and preservation of the environment come to the fore, the deficiencies of landfilling these materials are becoming evident. Organic sludges which are placed in a sanitary landfill, even a so-called properly operated one, constitute a water pollution threat. The
sludge can leach through the landfill and seep into ground water with possible detrimental effects to the quality of the water obtained from nearby water wells. Landfills are often located next to rivers or streams and a great deal of surface water pollution can occur during periods of high water should the stream flood the landfill.

In addition to the possibility of water pollution, a safety hazard exists with landfilling organic waste. Fires and explosions have occurred in landfills which handle liquid organics. The use of bulldozers to spread and compact solid refuse along with flammable liquids can cause sparks which have ignited the flammable vapors. A landfill fire, in addition to being a safety hazard also constitutes an air pollution problem. Because of these situations, some private landfill operators refuse to accept organic wastes at any reasonable price.

Because the landfilling of sludge can produce adverse effects upon environment in a number of different ways, many states are now considering or have invoked strict licensing requirements for landfill operations. Landfills qualified to accept organic liquids must satisfy the governing body as to water run-off, leaching, fire protection, and proximity to other land usage. There are landfills which, when properly designed and operated, can accommodate organic liquids. These, however, are sophisticated operations and are, perhaps, better termed chemical landfills. As regulations become effective, the number of landfills which will accept organic liquids is expected to decrease and cause increasing contracting and disposal costs. At present, it is not uncommon to pay up to 12 cents/gal for disposal plus hauling charges.

Also, the ever present question of liability will loom larger and larger, as citizen suits become more frequent. Last, but not the least deterrent to landfilling of organic liquids is the nuisance odor clause, which is a common part of air pollution control ordinances. Extremely small quantities of certain vapors are detectable and thus can become the overriding factor in the decision to permit or to prevent landfilling of organic liquids.

Commercially Available Incinerators

As the landfilling of organic liquid wastes declines, incineration seems to be increasing. At present, however, and in spite of advancing technology, many problems are still inherent in the incineration of organic waste liquids of the type discussed in this paper. Commercial type liquid waste incinerators operate on an atomization principle. Fuel is introduced into the unit through a nozzle consisting of small orifices. The nozzle is designed to introduce either high pressure air or steam into the waste fuel to break the waste into droplets. This increases the surface area and enhances combustion of the waste.

Most nozzle designs contain provisions to burn oil or gas simultaneously with wastes of a low heating value. Incinerators employing atomization are entirely satisfactory for burning many liquids; however, they are not suited for the disposal of wastes from resin and coating plants for the following reasons:

1. Many of the sludges contain partially polymerized resins which tend to undergo further polymerization in the nozzle and subsequently clog it. This can often be avoided by blending the sludge with waste solvent or fuel oil, but the cost may be prohibitive or these liquids may not be available.

2. The atomization units tend to be noisy due to the high pressures required for atomization and combustion air. Some of PPG's paint plants are located in areas where additional noise cannot be tolerated.

3. Depending on the composition of the sludge being burned, particularly suspended inorganic matter, a degree of effluent control is required after the combustion process. Actually, the burning of organic sludges represents a classical situation in which to invoke the "total environmental" concept. Incineration may well solve what is basically a water pollution problem but, in doing so, can be considered a success only if no other problems are generated, such as air or noise pollution. With this goal in mind, PPG set out to develop incineration units for the disposal of sludges generated in paint and resin plants.

OBJECTIVES

The objectives established for the incinerator designs were:

1. complete and smoke free combustion without atomization of waste liquids which have a wide range of viscosity;
2. ability to burn organic liquids containing dissolved and suspended solids;
3. no need for extensive air pollution control equipment;
4. low noise level;
5. self-sustaining combustion after initial pre-heating; and
6. potential for heat recovery and automatic operation.

The first three of the above objectives had to be obtained to provide satisfactory incineration of wastes at the coatings and resins plants. Atomization was considered impractical because of plugging of nozzles by the polymers and suspended solids. Also, the waste liquids from the paint plant contain pigments as finely divided inorganic solids. The conventional way to burn these without causing excessive stack emission, is to burn the liquid in suspension and then to remove the particles from the flue gases by a high energy scrubber. This was considered too
costly and impractical for installation at the production plants. Thus a unique incinerator system was desired which could burn the wastes without entraining the inorganic solids in the effluent gases. The other objectives are obviously those which are advantageous to any system and generally can be provided by properly applying known technology.

**NATURE OF ORGANIC WASTE LIQUIDS**

The waste liquids and organic sludges of concern during this development result from solvent recovery still operations and resin and paint process malfunctions which result in useless batches of materials. These sludges can vary over a wide range with respect to composition, viscosity, solids content, and reactivity. Viscosities may be as high as 10,000 centipoise at ambient temperatures and solids contents of 70 percent by weight are possible. They are usually combustible and have a heating value from 10,000 to 15,000 Btu/lb.

Of concern to the burning of the wastes is whether or not the solids are combustible. The solids in the wastes from the resin plants are combustible and consist largely of dissolved organic solids. However, in some cases, "seeds" will form in the process equipment or storage tanks to produce gelled solid particles as large as 1/4 in.

In addition to these, the waste liquids from the paint plants contain finely divided inorganic compounds as pigments and driers. The success of the development of an incinerator to burn liquids containing these noncombustible solids hinged on preventing them from being entrained in the combustion gases. Having accomplished this, no pollution control equipment would be needed to clean the hot stack gases.

**PROTOTYPE DEVELOPMENT**

The initial work in development of the incinerator systems consisted of the construction, testing, and modifications of full size prototype units. Because of a critical disposal problem at a resin plant, the first prototype was built to burn its wastes which were essentially all organic liquids and dissolved and suspended solids. The testing and modifications consisted primarily of establishing the proper configuration for introducing the combustion air and waste liquid into the combustion chamber. The unit was then modified to make the second prototype for the burning of liquids containing noncombustible suspended materials from paint plants.

Figure 1 is a photograph of the first prototype burning 200 gal/h of a resin waste. The unit consists of a 15,000 cfm forced air fan, combustion chamber and liquid metering pump. The combustion chamber was approximately 6 ft sq. and 12 ft high, with multiple air inlet jets at two opposite corners. The waste fuel admission and the combustion air pattern had been established to provide a
highly turbulent and stable flame within the lower portion of the combustion chamber. The air flow rate was constant and the temperature of the unit was controlled by means of a variable speed gear pump. Five different types of liquid resin wastes were burned in sequence with no need to make any equipment adjustments other than the speed of the pump. At all times, the outlet temperature exceeded 2000 F, and as the invisible and odor-free gas indicated, combustion was essentially complete.

Next the prototype incinerator was modified to burn waste liquids containing suspended inorganic solids. Structurally, the modified unit was quite similar to the initial unit except for certain combustion chamber and feed system modifications. The design provided for continuous removal of the non-combustible portion of the sludges from the combustion chamber. The tests indicated that the wastes could be burned without entraining the liquid, or its suspended solids in the gas stream. A typical example of the material which was burned contained 50 to 60 percent noncombustible solids and is shown in Fig. 2. The solids remaining after the combustible portion of the wastes were burned were dry, odor-free, and pose no problem for disposal in any type of landfill.

PLANT UNITS

Plant Unit for Resin Wastes

Figure 3 shows the incinerator which is operating at one of PPG’s resin plants. A gas burner mounted on the back of the unit is fired at 3,000,000 Btu/h to preheat the combustion chamber and smoke-free start-up of resin burning can be accomplished. Then the gas is turned off but air is maintained through the gas burner to prevent overheating.

Combustion air from the forced draft blower enters the refractory lined combustion chamber through several ports to provide the desired flame pattern. The numerous air pipes shown were built on this first unit to permit testing and adjustment as necessary. However, it was found that only about one third of these were needed for air admission and that all types of wastes to date could be burned under the same air flow conditions.

The sludges are fed into the combustion chamber in such a way as to minimize their being picked up and carried in the gas stream. Fuel for combustion consists of the vapors which are evolved from the surfaces of relatively large masses of the sludge exposed to the intense radiation from the flame and combustion chamber walls. Tests are being conducted to determine how effectively this feeding technique avoids particulate emission in the visually clear stack gases.

The refractory lined breeching between the combustion chamber and stack was installed for easy removal to provide a connection to a future waste-heat boiler. The plant at this location has a need for additional steam and studies indicated that heat utilization would yield an attractive return on the capital investment. The incinerator was located adjacent to the boiler house and the control center in the boiler room in preparation for the boiler addition.

The purpose of the 40-ft high, 64-in. diameter stack
was to permit the combustion chamber to operate at a negative pressure of approximately 0.04 in. of water. Observations and modifications were achieved more conveniently than would have been possible on a pressurized unit.

Figure 4 is a reproduction of a chart showing temperatures recorded while the incinerator was firing wastes automatically. The combustion air rate of approximately 7000 cfm was constant and the breeching temperature was maintained by automatic speed adjustment of the two feed pumps. Still sludges, adhesive slops, and waste resins have all been burned at rates over 100 gal/h with equal success, a clear stack, and with no auxiliary fuel required except during the initial preheat. The nearly
uniform breeching temperature maintained by automatic operation confirmed that heat recovery could be realized from the unit. The varying temperature of the thermocouple located in the combustion chamber reflects changes in the flame position within the chamber.

The incinerator is relatively quiet and normal conversation is possible adjacent to the unit. The most significant noise emanates from the fan inlets which have not been muffled. A sound meter reading about 6 ft from the incinerator registered 73 dBA. Sound measurements taken at some incinerators employing atomization have been recorded at 85 to 90 dBA.

Two feed pumps are used to meter the waste liquids to the incinerator and thus permit simultaneous burning of incompatible organic wastes. Each pump is driven by a direct current motor and solid state speed regulator. The ratio of the two pump speeds can be varied by a manual adjustment on the control panel while the total flow of waste to the incinerator is automatically regulated by the temperature of the gases in the breeching.

After the incinerator was in full operation, a third feed port was installed to permit the incineration of wastes which were predominantly water. Previously, these were injected into the gas-fired boilers of the plant, but this required the use of purchased fuel, resulted in high boiler maintenance, and the disposal rate was too low. When the organic wastes are being burned in the incinerator, aqueous wastes of at least 150 gal/h can also be disposed of. The automatic speed control on the pumps adjusts to maintain the proper breeching temperature irrespective of the proportion of combustible content of the aqueous waste.

**Plant Unit For Burning Wastes Containing Inorganic Solids**

At the time this paper was written a complete incinerator facility had been designed to burn 100 gal/h of the waste liquids from one of PPG’s paint plants. Construction is planned for the fall of 1971 and operating data should be available during the presentation of this paper.

This incinerator differs from the one described previously, primarily in the method of handling the sludges for the burning cycle. The design includes a rotating mechanical device, which will carry the sludge into the combustion chamber and the noncombustible residue back out. Outside the combustion chamber, the residues will be removed and collected from the rotating device by a pneumatic system and cyclone for subsequent hauling to a landfill.

Throughout the cycle of feeding, burning, and residue removal, the sludge will be confined to low turbulent portions of the combustion chamber. Thus, the liquids and their suspended inorganic particles will not be entrained or suspended in the gas stream. Radiant heat will evaporate the combustible vapors from the sludge mass and these will be burned in the upper portion of the chamber. Because the inorganic portion of the sludge will remain on the feeding device for subsequent removal, no air pollution equipment for cleaning the stack gases is planned.

Performance tests and final modifications to this unit will be made at the plant site. The design includes provisions for conveniently adjusting the air pattern, the temperature for vaporizing the combustible portion of the sludges, and the time of the sludge burning cycle.

**CONCLUSIONS**

The incinerators developed demonstrated that paint and resin plant sludges can be burned satisfactorily under automatic control and without the use of atomizing nozzles. Excellent and smoke-free combustion can be obtained at low noise levels by burning the vapors from the sludges and, at the same time, avoid the entrainment of the sludges in the gas stream. Particulate emission tests are to be conducted to determine how effectively the residue from burning sludges containing inorganic solids can be removed from the combustion chamber and collected without excessive emission in the combustion gases.

The possibility of heat recovery was demonstrated by the uniform outlet temperature that was automatically maintained while burning a number of different paint and resin waste materials. Performance tests burning other types of organic waste liquids will proceed as the development of the units continue.