HAZARDOUS WASTE AS SUPPLEMENTAL FUEL FOR CEMENT KILNS

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ABSTRACT

Cement kilns have many advantages for the disposal of select, ignitable hazardous wastes while simultaneously recovering their energy content. This paper discusses a supplemental fuel program conducted by us over the past 5 years in which over 35 million gal (13×10^4 m^3) of select hazardous waste have been utilized as supplemental cement kiln fuel.

INTRODUCTION

According to the federal definition of hazardous waste (40 CFR 261), a solid waste is a hazardous waste if it is specifically listed as such or if it meets one or more of the following criteria: it is ignitable, corrosive, reactive, or exhibits the characteristic of EP toxicity. Improper disposal of hazardous wastes, particularly in the liquid form, has all too frequently led to adverse health and environmental consequences. Migration of liquid wastes into groundwater is one notable consequence, culminating in the recent outright ban of placing certain hazardous wastes in landfills.

Although reduction of the amount of waste that is generated is the most desirable approach to the hazardous waste disposal problem, some amount of waste must ultimately be disposed. Incineration is a desirable method of disposal since organic compounds will generally be efficiently destroyed, and most combustion products are harmless or at least manageable with available control technology. The resulting residue is also considerably smaller in volume and generally far less hazardous than the original waste. If one of the hazardous characteristics of the waste is flammability, than that waste may qualify for a waste-as-fuels program. Thus, a two-fold benefit is achieved: the waste is destroyed and nonrenewable fossil fuel is conserved. This paper discusses the use of select, ignitable hazardous wastes as supplemental fuel for cement kilns in a highly successful waste-as-fuels program.

THE CEMENT KILN PROCESS

Cement production is an energy-intensive industry. Depending on the process, 35–65% of the production cost is for fuel. A typical wet process cement kiln may burn about 150 tons (140×10^3 kg) of coal a day to provide approximately 3.5 billion Btu's (3700 GJ) of heat. A cement kiln may be 10–15 ft (3–4.6 m) in diameter and 350–500 ft (107–152 m) in length. Figure 1 shows a schematic drawing of a typical wet process cement kiln firing supplemental fuels. The temperature at the firing end of the kiln may reach 3700°F (2000°C), but a minimum of 2600°F (1400°C) is essential for the

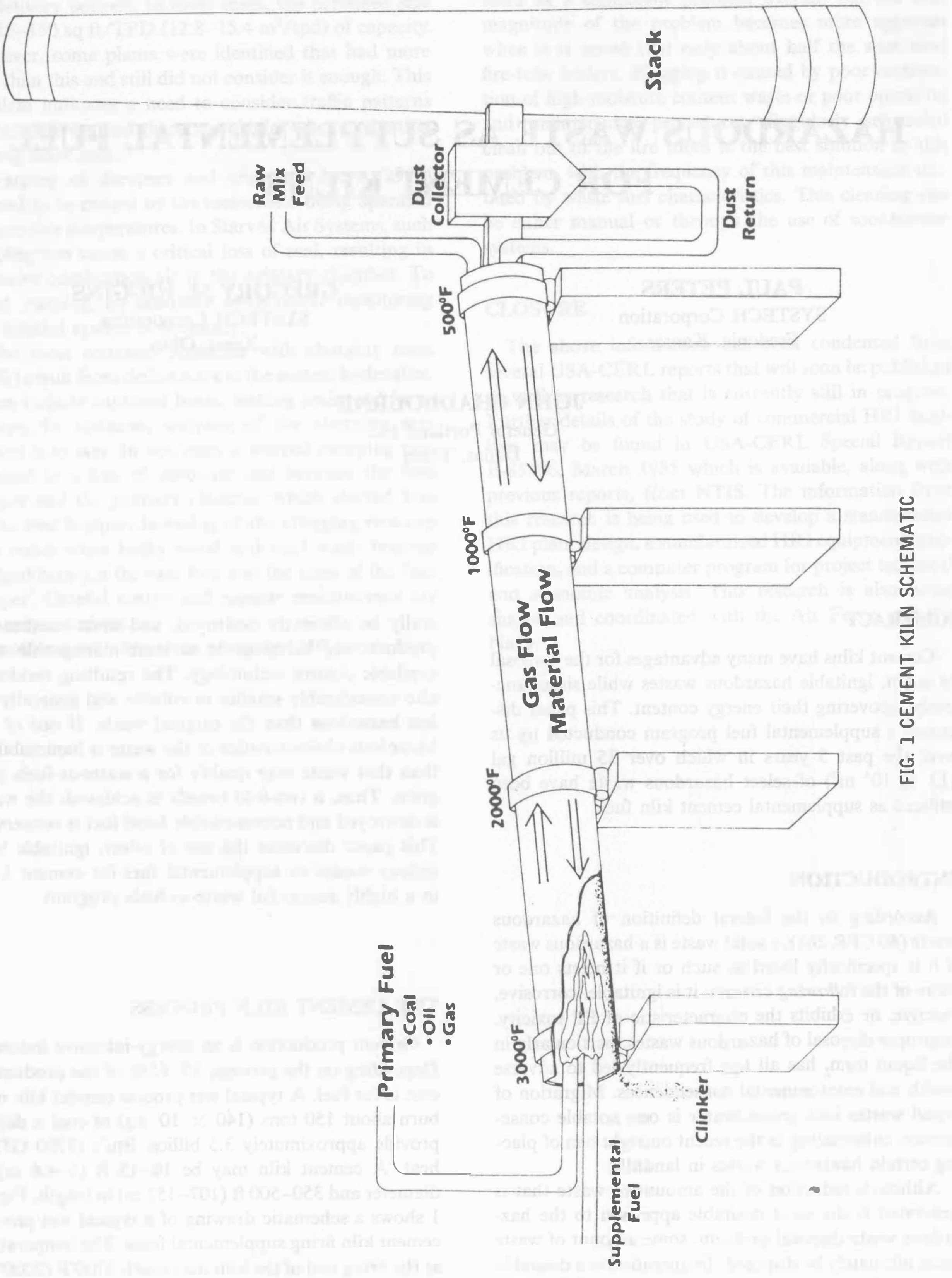

FIG 1 CEMENT KILN SCHEMATIC

calcinating reactions to occur. Other attributes of cement kilns are a turbulent burn zone, an alkaline environment, and a retention time of 3–5 sec at high temperatures.

These characteristics of a cement kiln form the basis of an excellent incinerator. Many studies have reported the effects of burning hazardous waste as a supplemental fuel in cement kilns [1–3]. Some of the studies looked specifically at troublesome waste constituents such as chlorinated solvents, PCB's, and Freon 113. Generally, all of these studies have shown destruction efficiencies exceeding 99.99% for the principal organic constituents (POHC's) and for more refractory tracers.

Virtually all of the metals introduced into the kiln, which includes those from supplemental fuel, coal, and raw materials, leave the kiln stabilized in clinker or in kiln dust [4]. Clinker is subsequently ground with gypsum to form cement. Some of the more volatile metals are found in the kiln dust which is removed by an electrostatic precipitator or a baghouse. Extensive studies [5] have shown that the metals bound in the highly alkaline kiln dust will not be leached into groundwater. Chlorides introduced in supplemental fuel are mostly found in the kiln dust because alkaline chlorides are volatile in the burning zone.

CHARACTERISTICS OF SUPPLEMENTAL FUEL

General Portland Inc. (GPI), a major manufacturer of cement, and SYSTECH Corporation, a technical services organization, have been developing and applying waste-as-fuel technology since 1979. Currently, GPI and SYSTECH operate three supplemental fuels facilities located in Kansas, Ohio, and California. These plants are supplying kilns with 25–50% of their heat requirements from supplemental fuel. The fuel is derived from hazardous waste and is regulated under RCRA. Operating experience and limits established in conjunction with regulatory agencies have led to clearly-defined parameters for acceptable supplemental fuel (Table 1).

The typical heat value of blended fuel is in the 11,000–12,000 Btu/lb (26–28 MJ/kg) range. This heat content is comparable to coal. The primary objective of the process is resource recovery through combustion in the cement kiln with the added benefit that wastes are destroyed. Wastes with little heat content are not of interest for the supplemental fuel program.

TABLE 1 CHARACTERISTICS OF SUPPLEMENTAL FUEL

Parameter	Maximum level (except as noted)
Organic compounds	
Acceptable	100 percent
Conditional	Specific limit
Unacceptable	<0.1 percent
Heat value	>10,000 Btu/lb (23 MJ/kg)
Visosity	100 cps (0.10 Pa × s)
Halogens	5 percent
Ba, Zn, Cr	3000 ppm
Pb	4000 ppm
Ash	7 percent
Solids	30 percent
Aqueous extraction pH	4 to 11

ENVIRONMENTAL, HEALTH, AND SAFETY CONSIDERATIONS

The first question that is often asked about a supplemental fuel program is "What comes out of the stack?" As mentioned earlier, the majority of field studies have found emissions of individual compounds to be 1 part per billion (ppb) or less. This includes some refractory organics and halogenated POHC's. Significant increases in hydrocarbon, CO, and other emissions may occur during kiln upset. This is equally true whether the kiln was burning coal only, or coal plus supplemental fuel [4]. Therefore, both CO and O_2 are continuously monitored and used to automatically shut off the injection of supplemental fuel in the event of upset conditions.

Another potential source of volatile organic compounds is the receiving and storage of the waste [3]. Our solution to this possibility is in the design of a totally-enclosed receiving, storage, and delivery system. Delivery vehicles are directly coupled via hose fittings to a pumping and filtering system, which in turn is hard plumbed to storage tanks. The storage tanks themselves are fitted with internal floating covers.

Piping leads from the tanks to pumps, a filter, and then to the kiln burner floor. Incidental spills from hose coupling, filter cleaning, or leaky seals are absorbed with kiln dust and removed to covered storage drums for proper disposal. Sump pits used for draining hoses are equipped with tight-fitting lids. Thus, a great deal of care is taken to control releases of vapors to the environment.

Many safety provisions are required by the RCRA legislation (40 CFR 264) for hazardous waste storage facilities. These regulations are designed to ensure adequate siting, containment, and fire protection. They also call for inspections, training, a safety manual, and Waste Analysis and Contingency Plans.

Another safety concern is transportation. At the Kansas facility, for instance, waste material arrives by tanker truck and rail car. To maximize safe movement of the waste, only state-approved hazardous waste haulers can be used. In addition, each transporter must be approved by us. Part of this approval requires, for example, comprehensive general and environmental damage liability insurance.

All waste movements are tracked by use of the Uniform Hazardous Waste Manifest. The manifest is a document that identifies the waste, indicates who is responsible for it, and allows verification that the load reached the proper destination. Any discrepancies in what was manifested and what was received are also noted on the manifest at the receiving facility.

Although the cement kiln is capable of destroying virtually any organic compound, certain chemicals are excluded or restricted in the waste received (Table 1). These exclusions or restrictions are designed for the protection of personnel who load, transport, unload, or otherwise stand at risk of exposure to the waste. They also ensure proper operation of the kiln for cement manufacture. Certain other compounds, such as PCB's, are prohibited because they invoke strong negative public reactions.

NEW COMPOUND ACCEPTANCE

For each organic compound encountered, a logical, objective method is needed to set limits of acceptability to ensure the safety of employees handling the fuel. To this end we have developed, with the assistance of industrial hygienists and toxicologists, an organic compound health effects evaluation model. The objective of the model is to provide a consistent and scientifically sound method for setting health-related concentration limits for organic components in the blended fuel. The model is designed to evaluate readily available data such as TLV's (ACGIH) and data from acute oral, inhalation, and dermal exposure studies in animals. Also considered are subacute skin and eye exposure studies, as well as a number of other toxicological, physical, and chemical parameters.

Component concentration limits are established by one of two methods, depending upon the availability of an assigned TLV. If a TLV is available, a concentration limit is determined using a formula derived by us which considers both the TLV of the component and its relative volatility. When no TLV is available, other data are used in a point rating system to assign concentration limits. Both methods result in placing a compound into one of the following categories: acceptable at 100%, conditionally acceptable at a specified level, or unacceptable.

The model is applied whenever a new compound is encountered in a qualification sample or tank tender. This process standardizes and expedites the process of compound approval. The model is a starting point that will evolve with experience and new data. To date, over 250 chemicals have been evaluated by the model. This list of chemicals, with their level of acceptance, is used at the plants to determine acceptance or rejection of the waste based on the organic composition.

QUALITY CONTROL

Every prospective generator of hazardous waste is required to submit a representative sample of the wastestream for evaluation. The sample must be accompanied by a signed questionnaire describing the origin and nature of the waste. The generator must also certify that none of a list of prohibited compounds are present in the waste.

The sample is then analyzed to determine its suitability as supplemental fuel. Volatile organic compounds are identified by gas chromatography with flame ionization detection. At the same time, an electron capture detector is used to check for PCB's. The heat content is determined by bomb calorimetry; and chloride, sulfates, and nitrates are measured by liquid chromatography. Atomic absorption or emission is used to measure the levels of lead, zinc, iron, titanium, barium, and chromium. Finally, other physical properties relevant to handling the waste are determined.

If the results of these tests indicate the waste is acceptable for blending as a supplemental fuel, the waste stream is submitted to the cement plant for approval. Following approval, the generator is qualified and may send waste to the site.

Each load of waste received at the site is weighed in and a representative sample of the material is withdrawn and analyzed to verify its acceptability. The manifest is examined for completeness. If all parameters are found to be within acceptable limits, the waste is accepted for unloading into the storage tanks. This total process can be accomplished in 2 hr, although longer periods may be required if problems are encountered.

When a storage tank is full, the contents are agitated and a sample is withdrawn. The tank sample must meet all of the criteria established for supplemental fuel (Table 1). The waste is then pumped to the kiln and used to supplement the heat input required for the cement manufacturing process.

CONCLUSIONS

We have successfully utilized over 35 million gal (13×10^4 m^3) of select hazardous wastes as supplemental fuel for cement kilns in the past 5 years. In order to ensure that these materials are handled safely and in compliance with all applicable regulations, detailed procedures have been established for evaluating and accepting the wastes and for the use of these materials as supplemental kiln fuel. The program described in this paper represents an important waste control technology which recovers energy from waste materials and simultaneously provides a safe and efficient method for their proper management.

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