INCINERATION OF EPOXY GLASS LAMINATES TO RECOVER PRECIOUS METALS

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ABSTRACT

An incinerator used for the combustion of certain epoxy resins to recover precious metals had been causing a large number of complaints due to excessive smoke and odors. A local manufacturer accepted the challenge of designing an incinerator capable ofcombusting the epoxy material under certain temperature limitations and eliminating the smoke and odors by completing combustion of the burnable gases in an afterburner.

A detailed discussion of the development, design criteria, and the construction and testing of the prototype incinerator at the plant site is included. Performance data on the old incinerator and the newly installed unit is given.

INTRODUCTION

Realizing the rapidly increasing problems created by air pollution, many industries are faced with several choices: 1) finding a method of eliminating their contributions to atmospheric contamination, 2) moving that portion of their enterprise to a more remote location, 3) cessation of operations that cause these pollutants. Moving offending operations to a more remote locality is usually prohibitive in cost and is only a temporary solution. Air pollution is already a national problem, in fact, an international problem since air currents recognize no boundaries.

General Refineries, Inc. of St. Paul, Minnesota was faced with an air pollution problem that dealt with the recovery of precious metals from electrical circuits printed on epoxy impregnated fiber glass laminates. This recovery meant incineration of the scrap and rejected printed circuits at controlled temperatures, which liberated a considerable amount of unburned hydrocarbons and obnoxious odors into the atmosphere much to the annoyance of their neighbors.

The plant was located on the fringe of the downtown area of St. Paul where industry merged with older residential buildings. The Director of Air Pollution of St. Paul requested several manufacturers of air pollution control equipment to consider the development of an incinerator to solve this problem. A manufacturer of incinerators located in suburban Minneapolis accepted the challenge. After months of testing in a prototype unit at their factory, a successful unit was installed that adequately solved this perplexing air pollution problem.

DEVELOPMENT OF DESIGN CRITERIA

It was most apparent that an afterburner would be required to consume the unburned hydrocarbons and other odor-producing compounds. At the same time, the primary combustion chamber temperature had to be kept below 700 F because of the tendency of the glass fibers to soften and inhibit separation from the metal.
need for a large combustion chamber was obvious owing to the burning characteristics of epoxys. Frequent firing of smaller charges seemed more logical since certain epoxys burn faster than others. Smaller more frequent charges would greatly reduce the tendency of excessive fluctuations of temperatures in the combustion chamber. A vertical unit seemed more desirable than a horizontal unit as it would reduce the possibility of smoke leakage around the feed door.

Checking the source of the materials to be incinerated revealed the glass laminates consisted of approximately 65 percent fibreglass (by weight) and 35 percent epoxy resins. We were informed that no chlorines were present and not more than a trace of sulphur. However, up to 16 percent petra-bromo was added to the resins to permit the use of the final product under various ambient temperatures.

No information could be obtained to indicate the heat of combustion but the testing did indicate the heat release to be extremely high. If further research does not produce this information, actual calorimeter tests will be made to assist in the further study of the incineration of epoxy resins.

A gas burner was necessary to start combustion; the burner had to be operated in such a manner that the gas supply could be controlled by a time clock adjustable from 1 minute to 15 minutes, depending on the burning characteristics of the epoxy being incinerated. It appeared desirable to provide air for combustion by allowing the gas burner fan to operate continuously rather than depend on gravity to supply the air needed. Combustion took place on a hearth rather than on grates as it would simplify the recovery of the precious metal.

Insulating type firebrick capable of withstanding temperatures of at least 2400 F was thought to be desirable in the afterburner chamber in order to reduce preheat time and inspire fuel economy. The afterburner was sized so as to be capable of maintaining afterburner chamber temperatures of 2000 F and so that it could be located in such a manner as to provide near-perfect mixing of the gas flame with the incoming products of combustion from the primary chamber.

No published information was found that indicated temperatures required to completely crack the heavy hydrocarbons liberated by the initial combustion process, nor could information be found as to the burning rates of similar epoxy resins. The best sources stated that temperatures of about 2000 F were required to burn natural and synthetic rubbers and most polyesters in order that emissions would be free of color and odors.

**CONSTRUCTION AND TESTING OF PROTOTYPE UNIT**

With the information accumulated, a prototype unit was assembled to start testing. A standard multiple chamber vertical incinerator was erected on a test pad, complete with one burner in the combustion chamber and one in the secondary chamber. The initial burning of the test material produced considerable smoke, odors, and leakage around the feed door was most obnoxious. Burner adjustments and controlled feeding were indicated.

The feed throat was bricked shut and the supply of materials to be incinerated was charged into the unit through the ash door. Leakage of smoke and odors persisted, although materially reduced. At this time a 42 in. high section was added between the primary and secondary chambers. This eliminated all leakage as the added combustion-chamber height proved the needed volume to contain the surge of gases liberated at the start of each firing period.

*FIG. 1 SAMPLING OF STACK GASES*
Thermocouples to measure gas temperatures were placed near the top of the combustion chamber in the afterburner chamber, in the stack just below the barometric damper, and ten stack diameters above the barometric damper where the flue gas sampling ports were located.

Temperatures in the combustion chamber averaged about 450 F with peaks up to 700 F, but temperatures above 1600 F could not be achieved in the afterburner chamber. As a result, considerable smoke and odors were discharged into the atmosphere at the start of each burning period. A second afterburner was added to obtain temperatures of 2000 F. This cleared up the emissions considerably, but was not satisfactory to the test crew. Redesign of the partition between the combustion and afterburner chambers and relocation of the gas burners eliminated visible emissions from the stack.

Arrangements were then made for the initial test (Fig. 1) which was witnessed by members of the air pollution staff of both Minneapolis and St. Paul. Approval to proceed was given at this time with assurance that permits would be issued.

**DESIGN AND INSTALLATION OF NEW UNIT**

After successful testing of the prototype unit, plans for the new incinerator were prepared including a new feed-door arrangement to provide adequate charging facilities and to be as gas tight as possible. The combustion chamber was to have a volume of 191 cubic feet and the afterburner chamber a volume of 43 cubic feet. Twenty feet of 16 in. refractory-lined stack would raise the stack discharge to approximately 38 feet above the incinerator base. (See Figs. 2, 3 and 4).

A control system was designed that should assure proper burner operation and unit temperatures and the same time be flexible in case adjustments were necessary in the new unit. Control of the primary burner was manual but a timer could be added if required. The afterburner con-
The controls consisted of a West Model JT3 indicator controller, a K14F thermocouple and a K8K5W protection tube. The thermocouple was located in the afterburner chamber out of the firing line of the burners. This controller operated the relays of the two Model IBA Barber gas burners rated at a maximum of 1,200,000 BTU/hr (natural gas). A duplicate couple arrangement was installed in the combustion chamber and connected to a west Model “I” indicator. The controls along with power supply switches were located inside the building near the incinerator.

**TESTING OF UNIT**

The completed unit was installed early in January of 1967 and field testing was started immediately. (See Fig. 5). It was not until actual operation commenced that it was discovered there were several type of epoxys to be combusted. These epoxys, distinguishable by color, could be roughly divided into three types, depending on the ignition temperatures and burning rates of the materials.

It was ascertained that one type burned readily and required less heat to start combustion. In fact, the combustion chamber burner was only used to start the burning process. The other two types of epoxys burned cleanly with the gas burner operating continuously. However, the gas input to the combustion chamber burner was found to be quite critical, and some excess secondary air was indicated. An adjustable air inlet was added to the side of the feed throat and no further modifications were required for the combustion process.

In the end, the afterburners were adjusted so that one burner operated continuously; the other burner was set to turn on at 1850 F and shut off at 2000 F.

After the several weeks of field testing, adjusting, and training of the operating personnel was complete, the incinerator was turned over to the company for acceptance.

**FIG. 5 TESTING RIG**

**PERFORMANCE**

Dust loading tests were made on the stacks of both the old and new incinerators while similar epoxy materials were being burned. Western Precipitation stack sampling equipment was used for both tests with suction provided by a Willson pump. The dust samples were collected isokinetically in fiberglass sock filters. Owing to certain limitations, only one sample was collected when the old incinerator was in use. A stack sample of particulate matter from a total volume of 35 ft³ of waste gas, was
collected using a flow rate of 1.3 cfm and a nozzle size of 3/8 in. The dust loading for the old incinerator was found to be 1.2160 grains/SCF.

After a reasonable trial period, the performance of the new incinerator was evaluated. Four samples of dust, each representing 30 ft³ of stack gases were collected while charging 30 lbs. of epoxy scrap every 10 minutes (180 lbs. per hour burning rate). (See Fig. 6 for samples of scrap.) A flow rate of 1.12 cfm and a nozzle size of ½ in. were used. The dust loading from the operation of the new incinerator was calculated to be 0.1968, 0.1785, 0.2514 and 0.2271 grains/SCF with an average of 0.2134 grains/SCF. This represents a reduction in dust emissions from the old incinerator of 83 percent.

During the 2½ hour testing period continuous Ringelmann readings were made using full scale charts in accordance with the method outlined by the Bureau of Mines (See Fig. 7). During one two-minute period, readings of from No. 1 to No. 3 were taken, averaging No. 2 Ringelmann. With the exception of an additional one half minute of No. 1 Ringelmann, the balance of the 2½ hour tests showed very little or no visible plume. The higher readings were the result of a switch from coarse scrap to fine scrap which increased the burning rate. Adjustment of the combustion chamber burner to compensate, corrected these conditions.

The test data indicated stack velocities at the gas sampling port to average 55 feet/second. Velocities of gases entering the base of the stack were calculated to be approximately 43 feet per second. Velocities through the opening between the combustion and afterburner chambers could not be computed since the heat released from the epoxy in the primary chamber was not known.

CONCLUSION

Installation of the new incinerator enabled the customer to continue incineration of the epoxy laminates at their present location during normal working hours. Since its installation ten months ago, the St. Paul Air Pollution Control Department has received only one complaint. This was registered during the initial adjustment of the unit. The operation of the old incinerator had brought a continuous flow of complaints from neighbors, which forced limitation of the operations to favorable wind conditions and high barometric pressures. In spite of these precautions, complaints continued.

Because of the variance in type and consistancy of the epoxy scrap, trained personnel must be in constant attendance during the first several minutes of each firing period.

It is reported the new incinerator simplifies the recovery yield of the precious metals due to more consistant ash quality. This helps defray cost of fuel consumed by the three burners.

Polyesters and other plastics, as well as wool and vinyls have since been burned in this incinerator, all with equal success.