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AIR POLLUTION FROM DISPOSAL OF JUNK AUTOS

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ABSTRACT

Air pollution from the disposal of junk automobiles has been a problem for many years, and is still a significant nuisance in some areas of the United States. The magnitude of the automobile disposal problem in America is discussed, as is the problem of air pollution from the processes involved. Descriptions of both the incineration and disintegration processes are given. Emphasis is placed on the economics involved in the disposal of junk automobiles and on increased restrictions on open burning. New processes under development are discussed.

The paper is a summary of a report on a National Center for Air Pollution Control study on the disposal of junk automobiles and air pollution from such disposal.

KEY WORDS

Scrap Yards
Incinerators
Emissions Inventory
Smoke Shade
Ringelmann Chart
Particulate Sampling
Stack Sampling
Afterburners
Electrostatic Precipitation
Scrubbers
Acids Organic
Aldehydes
Hydrocarbons
Nitrogen Oxides
Field Tests

AIR POLLUTION FROM THE DISPOSAL OF JUNK AUTOS

INTRODUCTION

This paper is a summary of a report of air pollution from the disposal of junk automobiles. It summarizes the findings of a study begun in 1966 in which a review of the literature and "on site" observations of junk auto disposal were made.

Visible air pollution from the disposal processes was judged by opacity using the Ringelmann chart rather than a measurement of the particulate matter.

The burning of junk autos has caused visible air pollution for many years. This pollution is still a significant nuisance in some sections of the nation. The open burning of autos emits excessive amounts of black smoke and other contaminants.

Methods used to dispose of junk autos have changed over the years. Restrictions on open burning led to the use of batch incinerators with limited control of air pollution. Batch incineration evolved into continuous tunnel incineration that incorporated improved control of pollution. Decreased demand for compressed, incinerated auto scrap, known as No. 2 bundle, and more stringent local smoke abatement have caused the cessation of many batch and tunnel incinerators. Economic and engineering problems recently forced the shutdown of a newly developed mechanical disintegration and incineration process, which made use of adequate air pollution control.

Economics have encouraged installations that use two established processes, which have virtually eliminated the burning of junk autos. These processes use mechanical disintegration and separation equipment with excellent control of atmospheric emissions. Market demand for fragmented scrap, the product of both processes, is adequate even though recent domestic market conditions have curtailed process capacities at some locations.

Several newer concepts for disposal of junk autos that are being developed hold promise of success. One concept is to dissolve partially stripped autos in molten iron in either vertical-shaft or inclined-shaft furnaces. Another idea is to use shredded auto scrap to upgrade nonmagnetic taconite to magnetic iron using a continuous kiln process. A third concept is to mold concrete around dense compressed auto scrap to form lightweight building blocks. The air pollution control methods for these new concepts are under development.

MAGNITUDE OF AUTO DISPOSAL PROBLEM

Air pollution from the disposal of junk autos presents challenging technological and economic problems. Yearly increases in auto registrations and in the number of scrapped autos have intensified these problems. Technological advancements made by the steel industry, which is the major consumer of auto scrap, have caused a demand for higher quality scrap. Consumption of auto scrap has decreased because its quality is not high enough.

Auto registrations rose from 40.3 million in 1950 to 71.9 million in 1965.[1] The number of autos scrapped increased from 2.60 million in 1950 to 9.69 million in 1965.[2] The number of autos to be scrapped in 1970 is projected at 10 million.[2] Accumulation of discarded autos presents an ever increasing health problem and an eyesore nuisance. The auto scrap industry in the United States historically has been dependent on the vigor of open-hearth steelmkaing. The advent in 1950 of the basic oxygen furnace (BOF) for steelmaking has caused a decrease in the amount of auto scrap used per ton of finished steel. Figure 1 illustrates the decrease since 1950.[3] The open-hearth furnace uses about 45 percent scrap and the BOF uses only 25 percent scrap.[3] Future steelmaking installations will use more BOF[3] processes.

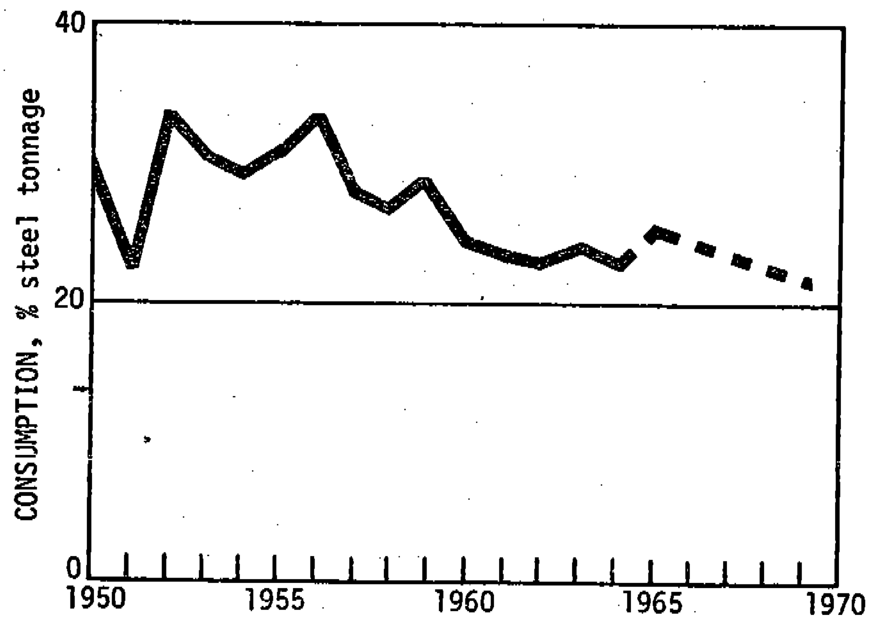

Figure 1. Yearly Scrap Usage in United States.

Lower market demands and improvements in steel quality have required the scrap iron industry to upgrade quality. The steel industry gauges the quality of ferrous scrap by using the percent of copper contained in the scrap as a yardstick. High copper content lowers scrap quality. No. 2 bundles vary from 0.07 percent to 2.79 percent copper.[3] Fragmented scrap varies from 0.25 percent to 0.80 percent copper; the higher value is obtained if the heavy melting scrap from axles and transmission is removed.[3] The steel industry has reported a 15 percent melting loss from scrap purchased on the open market as No. 2 bundles while scrap purchased from fragmentizing plants has only a 5 percent melting loss.[4] Finished steel quality has improved and copper limits for various steel grades vary from 0.01 percent to 0.05 percent.[4] Obviously, the steel industry desires to purchase scrap with low melting loss and an amount of copper as close to the finished steel quality as economically possible. In the future, continued pressure on the scrap industry for higher quality and lower prices may be expected. Fortunately, the foreign steel industry is still purchasing lower quality No. 2 bundles and is buying fragmented scrap at premium prices. Foreign purchasing provides the domestic scrap industry with lead time for resolving the disposal problem of junk autos.

AUTO STRIPPING

Auto stripping is a method for preparation of junk autos for further processing to make salable scrap. The degree of auto stripping depends on whether the stripped auto is processed by incineration or by shredding with a fragmentizer.

Usually the auto is stripped more completely when processor uses burning to purify the ferrous metal in a scrap auto. Engine and radiator are removed for sale as salvaged parts. Gasoline tank is removed for safety. Tires and seat cushions are taken out to reduce smoke emissions from auto incineration. Transmission, axles and copper wiring may be removed before or after incineration. If high grade No. 2 bundles are made after incineration, the degree of copper stripping is more complete.

Junk auto stripping for sale to a fragmentizer usually includes the removal of motor, gasoline tanks, tires and wheels and seat cushions. Normally, copper wiring is not removed. For a small or medium fragmentizer, the axles and frames are removed to lighten the load on the shredding mill.

AUTO DISPOSAL PROCESSES

Two classes of auto disposal processes are currently used. They are auto incinerators and auto disintegrators.

Incineration Processes

Open burning of junk auto bodies to prepare the steel for compression into dense bundles was practiced for years by auto wreckers. The black smoke from the partial combustion of paint, sound deadening materials, rubber, upholstery, wire installation and plastic caused many complaints in urban communities.[5] Local and state abatement of open burning has led to the development of auto incinerators that better control atmospheric emissions. Auto incinerators usually have a primary combustion chamber where auto burning occurs. Combustion gases from the primary chamber pass through an afterburner or other control device before discharging to the atmosphere. Both batch and continuous incinerators, which produce No. 2 bundles, were visited during the study. Data gathered are presented herein.

Batch incinerators for small scrap yards often are pit incinerators with afterburners. Temperatures in afterburners are kept at 1400° to 1500°F to control atmospheric emissions. Figure 2 shows a pit-type incinerator. Such incinerators usually have a daily capacity of about 8-12 autos. Properly designed and operated pit incinerators control atmospheric emissions to an opacity

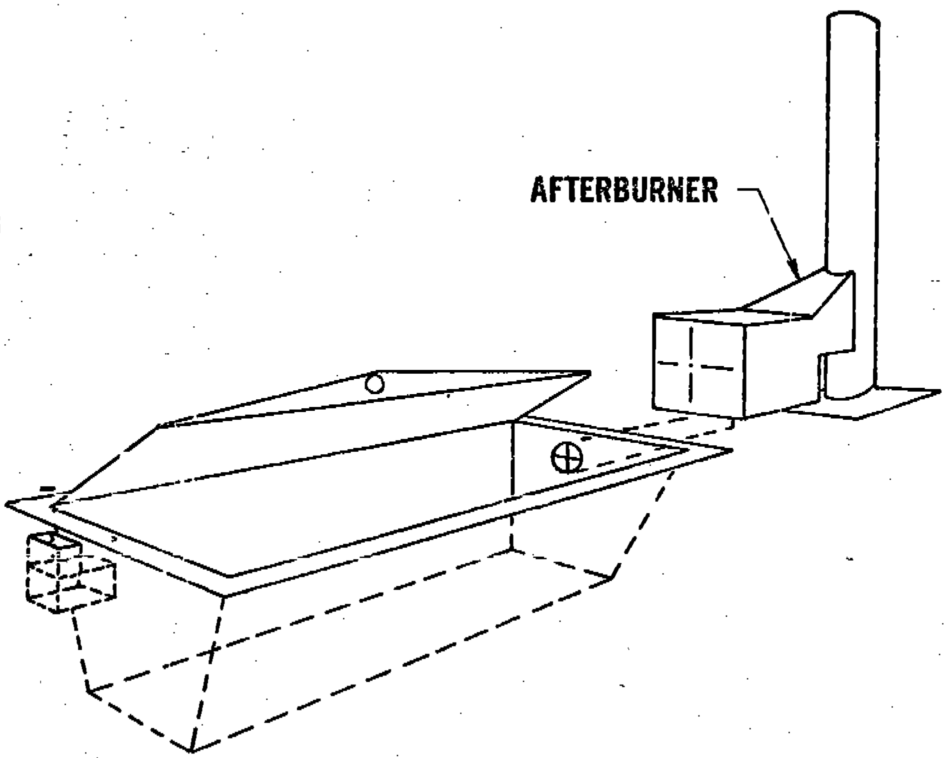

Figure 2. Pit-type auto body incinerator.

equal to or slightly less than No.2 Ringelmann. Uneconomical operation and/or more stringent local abatement action have caused the two pit incinerators visited to be shutdown.

Larger batch incinerators are usually garage incinerators with afterburners. Temperatures in afterburners are kept at 1400° to 1500°F to control visible emissions. Figure 3 shows a garage incinerator. Daily capacity of this type of incinerator is about 40-45 autos. Properly designed, maintained, and operated garage incinerators control visible emissions during burning to an opacity of less than No. 2 Ringlemann. The

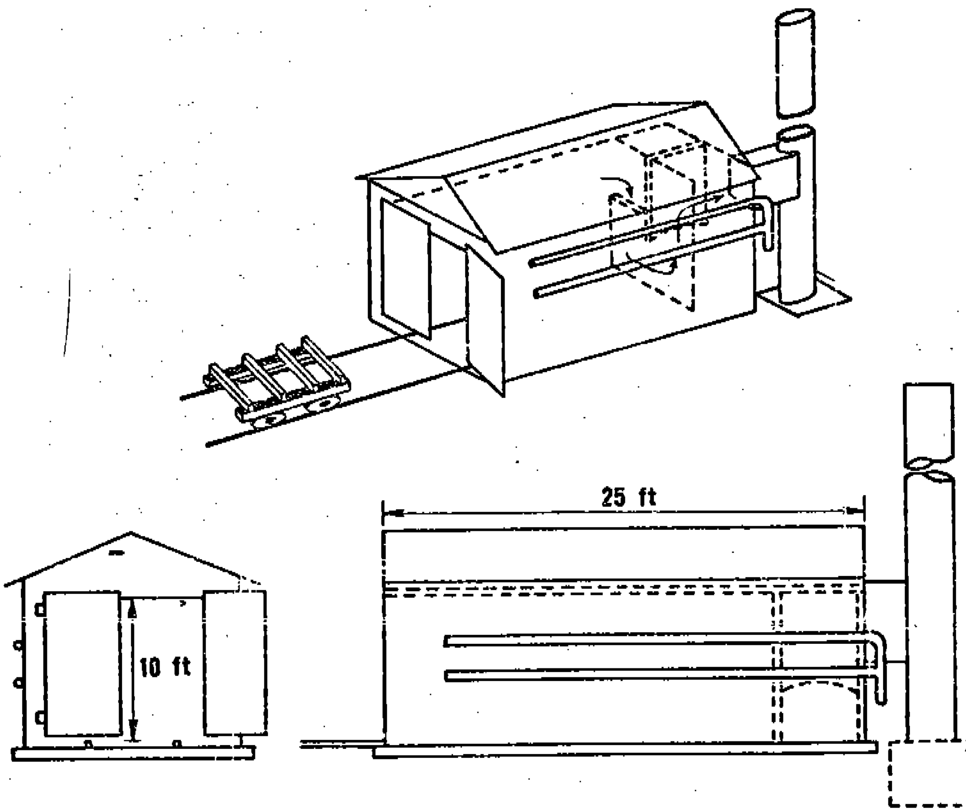

Figure 3. Garage-type auto body incinerator.

economics and more stringent local abatement action have caused one of two incinerators visited during the study to be shutdown. The other unit operates whenever economics are favorable.

Another large-batch unit visited is a tunnel design with a wet-type electrostatic precipitator to control atmospheric emissions. The owner uses careful hand stripping to produce a high grade No. 2 bundle that is purchased by a local steel mill. Annual maintenance costs on incinerator and electrostatic precipitator are 7 percent to 10 percent of original cost. The unit is successful in an area where a rotary kiln incinerating chopped auto scrap can not maintain solvency.

Continuous incinerators are used for capacities of more than 50 autos per day. Conveyors move autos through a tunnel-like combustion chamber. Exhaust gases from combustion pass through an afterburner or an electrostatic precipitator before discharging to the atmosphere. A continuous flow of autos through the chamber permits orderly preparation of autos prior to incineration to minimize processing costs. Figure 4 illustrates a tunnel incinerator on which a gas-fired afterburner controls visible emissions. An air lock with double doors at the tunnel entrance and a unique water pit at the exit are incorporated into the incinerator's design. Under-fired air used in combustion is drawn from the air lock at the entrance. The water pit serves as both a seal and a quench tank. Visible emissions

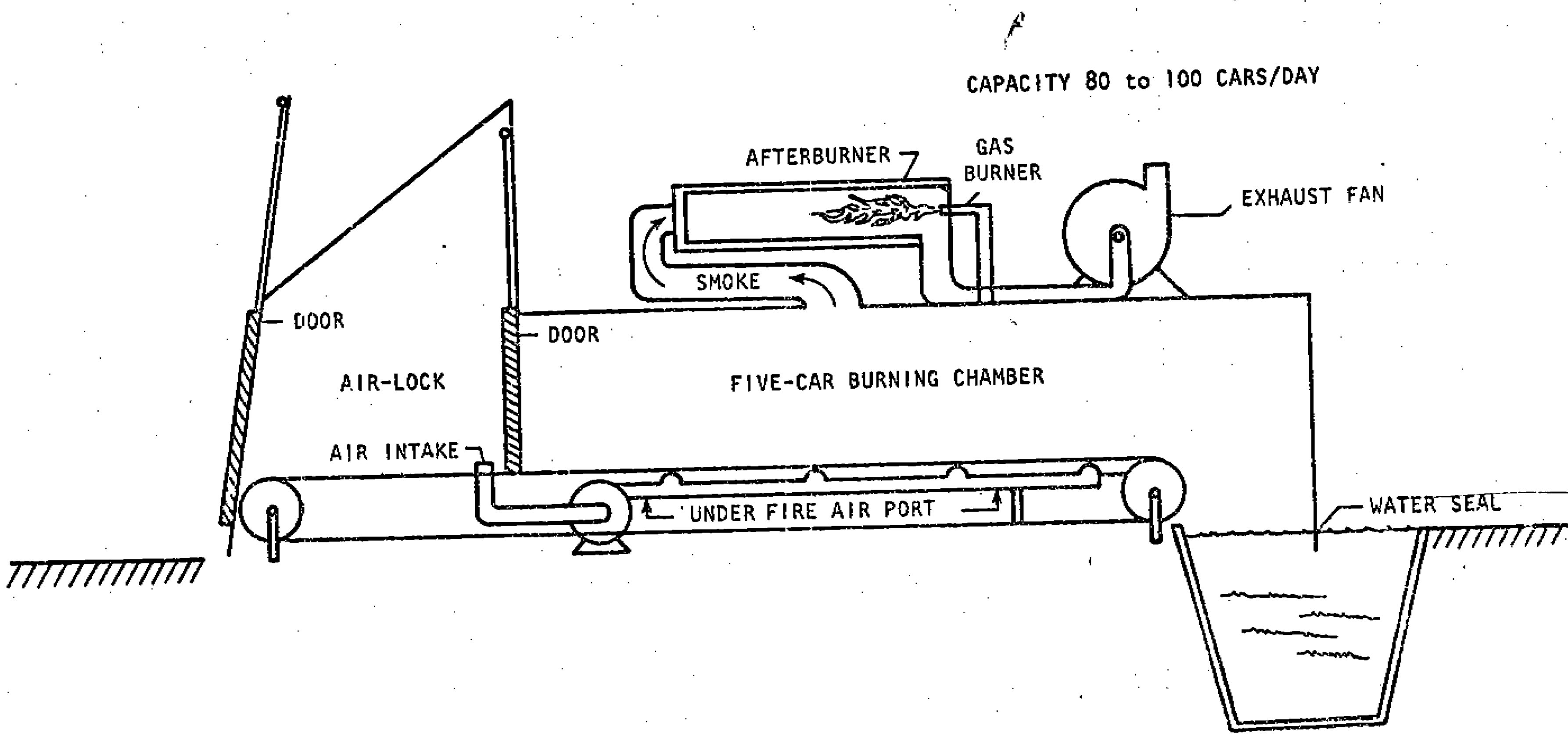

Figure 4. TUNNEL AUTO BODY INCINERATOR

from the incinerator have an opacity equal to or less than No. 1 Ringelmann when the unit is maintained and operated correctly. However, all continuous tunnel incinerators have been shutdown because of excessive operating and maintenance costs, more stringent abatement action and the economics of the industry.

A rotary kiln unit for burning chopped auto scrap was visited during the study. The process uses a gas-fired afterburner and two parallel disc scrubbers to clean combustion gases before discharging them to the atmosphere. Visible emissions from this incinerator process have less opacity than No. 1 Ringelmann. Engineering and operating difficulties and unfavorable economics have forced the shutdown of the unit. A summary of the incinerators visited is shown in Table I.

Emission Control Devices for Auto Incinerators - Gas or oil-fired afterburners are used as a secondary air pollution control method in most of the auto body incinerators observed. Results from a limited number of stack tests indicate that afterburners are effective in reducing gaseous and combustible particulate emissions from auto incinerators (Table 2). Visible stack emissions are reduced to less than one-half of No. 1 Ringelmann when afterburner temperatures and residence times are properly maintained.[6] Particulate grain loadings from one unit tested, (Table 2, Unit I) were reduced from about 0.54 grain per standard cubic foot, (adjusted to 12 percent

Table 1. DESCRIPTION OF AUTO BODY INCINERATORS OBSERVED DURING STUDY

No.	Type	Capacity Cars/day	Approximate Installed Cost	Air Pollution Control Device	Year Constructed
1	Batch (Pit)	8-12	$ 8,000	Oil-fired afterburner	1958
2	Batch (Pit)	10-15	10,000	Oil-fired afterburner	1959
3	Batch (Garage)	25-30	20,000	Gas-fired afterburner	1961
4	Batch (Garage)	40-45	55,000	Oil-fired afterburner	1965
5	Tunnel Batch	30-45	85,000	Electrostatic precipitator	1951
6	Tunnel	65-70	125,000	Electrostatic precipitator	1965
7	Tunnel	85-100	110,000	Gas-fired afterburner	1962
8	Tunnel	120-130	300,000	Electrostatic precipitator	1960
9	Rotary Kiln	150-160	500,000	Gas-fired afterburner Flood disc scrubber	1966
10	Tunnel	350-400	600,000	Oil-fired afterburner	1958

CO_2 ,) to .20 grain per standard cubic foot (adjusted to 12 percent CO_2,) by an afterburner.[6] Stack gas temperature averaged 850°F without afterburner operation and 1440°F with afterburner operation. These test results agree with those from another auto body incinerator equipped with an afterburner. The second unit showed an average particulate grain loading of 0.27 grain per standard cubic foot, (adjusted to 12 percent CO_2) when the afterburner was operating at an average temperature of 1532°F.[6]

Organic acids were reduced from about 0.61 to 0.21 pound per hour (Table 2, Unit I) by afterburner operation.[6]

Unit I is a small batch auto body burner. Its steel primary chamber holds one auto. The afterburner used on the unit is a two-pass firebrick lined chamber that is heated with four gas burners, each of which uses 485 cubic feet of gas per hour.

Unit II is a larger incinerator with a refractory lined primary chamber that holds two autos. The afterburner is a refractory lined, checkwork chamber heated by an oil burner with a heat output of 4 million 800 thousand Btu per hour (35 gallons oil per hour).[6]

The data for emissions from open burning were obtained by using a specially designed apparatus to collect combustion products and simulate, as nearly as possible, open burning.[7] Tires, floor mats, and seats from scrap autos were burned during the test rather than complete auto bodies.

Table 2. AUTOMOBILE INCINERATION EMISSION TEST DATA

	Unit I				Unit II	Simulated open burning
	Afterburner on		Afterburner off		Afterburner	
	Test 1	Test 2	Test 1	Test 2	On	
Gas temperature, ^{o}F	1390	1490	850	850	1532	-
Gas flow, scfm	3400	3200	3500	3500	4200	-
Particulates, grains/scf @12% CO_2	0.26	0.16	0.63	0.45	0.27	7.7
Organic acids	avg 0.068 lb/car 0.15 lb/hr	0.26 lb/hr	avg 0.20 lb/car 0.57 lb/hr	0.66 lb/hr	-	16 lb/ton material burned
Aldehydes, ppm	3	3	16	16	-	-
Nitrogen oxides, ppm	46	47	40	23	-	-
Hydrocarbons, lb/ton of material	-	-	-	-	-	30
CO_2, percent by volume	5.5	6.3	4.0	4.5	7.3	-
Visible emissions	<3 min. No. 2 Ringelmann		>3 min. No. 2 Ringelmann		<No. 1/2 Ringelmann	No. 4-5 Ringelmann
Afterburner fuel consumption	64CFM	64CFM	0	0	22 gal/hr	-
Unit capacity	3 cars/hr				3 1/2 cars hr	

One tunnel-type auto body incinerator equipped with an electrostatic precipitator was observed in operation. The unit capacity was three and one-half autos per hour. The electrostatic precipitator controlled atmospheric emissions to an opacity of less than one-half of No. 1 Ringelmann.

Two operating factors are important to the control of emissions from the unit. Proper humidity must be maintained in exhaust gases to facilitate collection of smoke and other contaminates by the precipitator, and equipment must be kept in proper working order to maintain collection efficiency.

Control of visible emissions from auto incineration by use of an afterburner and water scrubbers was observed during the study. Atmospheric emissions equal to or less than one-half of No. 1 Ringelmann in opacity were emitted. Combustion gases pass through the afterburner and then into two parallel, flooded disc scrubbers before discharging to atmosphere.

Disintegration Processes

Auto disintegrators are a relatively new development in the disposal of junk autos. Two large fragmentizer processes, which disintegrate entire automobiles have been developed. Medium and small shredder processes in which stripped auto bodies are cut into small pieces and fed to a shredder have also been developed. The quality and sale price of fragmented or shredded scrap is usually better than scrap in a No. 2 bundle.

Large fragmentizers that were visited are massive units with daily capacities of about 1000 autos. Little or no burning is done and control of dust generated in disintegration and separation operations is excellent. Visible emissions from processes are less opaque than one-half of No. 1 Ringelmann. High-efficiency cyclones dust collectors and fabric filters or wet scrubbers are used to contain process dusts. Installation costs for fragmentizers vary from $1.5 to $3.0 million and do not include cost of auxiliary equipment and land.

The design of medium and small shredders is somewhat similar to large fragmentizers. Control of visible emissions from medium or small units is reported as less opaque than one-half of No. 1 Ringelmann.[8,9,10] Small shredders handle 80 to 120 autos per day and medium shredders handle 150 to 200 autos per day. Cost of these units varies from $200,000 to $400,000.[8,9,10]

NEW DEVELOPMENTS IN AUTO DISPOSAL PROCESSES

Many concepts for the disposal of junk autos have been propsoed, but most have not been developed for enough to include air pollution control equipment.

The Bureau of Mines has many ambitous programs for disposing of ferrous scrap from junk autos and other sources.[11] Two of the most promising processes are pyrometallurgical purification of chopped auto scrap and combination of chopped scrap with low grade, non-magnetic taconite ore to make a material higher and more consistent in iron content. Although initial results of tests on both processes are encouraging, further investigations on a larger scale are needed to prove process integrity.[11] The air pollution control equipment for these processes has not yet been finalized.

A novel concept for dissolving stripped, whole junk autos in a molten iron bath contained in either a vertical-shaft or an inclined-shaft furnace has been proposed.[12] The auto enters the top of furnace where it decends slowly. It passes through incinerating and preheating zones into a dissolving zone. The idea has shown some success in a pilot plant investigation but additional development work is needed. No control for air pollution created by the process has been proposed.

A pyrometallurical process also has been proposed.[13] Stripped junk autos are placed in a rotisserie oven where they pass through three different temperature zones. The first zone incinerates conbustibles and melts out lead, the second zone melts out aluminum, and the third melts out copper. The incinerated auto is then cooled and compressed into a dense, pruified scrap bundle by a hydraulic press. The unit processes 120 autos per day. Estimated installation cost is $400,000.[13] No information is available about air pollution control equipment that will be used.

An engineering firm researching the problem has developed a process for making lightweight building blocks of concrete molded around compacted auto scrap.[14] The scrap-cored blocks are being tested to determine if walls made with such blocks can bear loads comparable to walls built with solid concrete blocks. In the manufacture of the blocks, junk autos are incinerated, sectioned, compressed, and encased in two inches of concrete. No information about air pollution control equipment is available.

CONCLUSIONS

Restrictions on open burning and unfavorable economics experienced by operators of auto incinerators have increased the use of fragmentizers for disposal of junk autos. The visible emissions from these processes are low, less than a no. 1 Ringelmann. Obviously, the fragmentizer offers a partial solution to the disposal problem for large metropolitan areas. Even here, domestic pressures for high quality and lower price scrap may seriously affect process economics if foreign sales are reduced. Only large metropolitan areas generate enough cheap and easily available junk autos for a large fragmentizer. A medium and small metropolitan area may benefit by installation of a medium or small auto shredder or macerator. Careful consideration of the scrap market and availability of junk autos is necessary before investing capital in a fragmentizer or shredder.

Research processes now being developed hold promise of other methods for economic utilization of scrap from junk autos. These processes, however, are several years from maturity.

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