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Project Summary

Investigation of Fluid Bed Combustion of Municipal Solid Waste

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A systems study was conducted for a co-generation, 300-tons/day power plant to be located on the Stanford University campus to supply all of the process steam requirement and as much of the electrical power as possible. The size of the plant was determined by the estimated available processed MSW supply in 1983. Preliminary design of components based on the 300-hour test results and cost estimates were made. It was estimated that the total plant investment for the co-generating plant, 6.7 MWe average and 200,000 pounds per hour of steam average, would be 23.1 million dollars, exclusive of fuel processing and transportation costs.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

A concept which utilizes fluid-bed combustion of municipal solid waste was investigated for application to the power generation and steam supply at Stanford University. Preliminary investigation of the system has shown considerable economic promise, although the operation of an atmospheric fluid bed containing steam-generating tubes had not been tested. Therefore, a program was recommended to the Department of Energy and the U.S. Environmental Protection Agency which would involve an experimental program to burn solid waste in a fluid-bed combustor and to undertake a more detailed economic study.

An experimental program was designed to investigate the favorable operating regimes for a bed with steam-raising tubes, to determine the combustion corrosion of the tubes, and to investigate the fouling of the tubes or system internals caused by the combustion of municipal solid waste. Two 50-hour preliminary experiments were run in order to shake down the equipment and to conduct a parametric study to specify the most favorable operating regime for a subsequent 300-hour test. All of these experiments were conducted in a 7 ft^2 atmospheric fluid bed located at the Combustion Power Company (CPC) in Menlo Park, California.

An economic study was also undertaken to determine the promise of the system as defined from the results of the experiments. As described below, a complete system was envisaged for application to the Stanford University campus, and the sizing and performance of the fluid-bed, solid-waste combustor was based on the experimental results. The application to Stanford University was used only as a specific application and was not necessarily the most favorable one, because of the wide variety of requirements for electric power and steam. However, it was felt that this would be a typical situation and that there would be considerable benefit in having a study made to meet definite, realistic requirements.

In the final report, the proposed system at Stanford University is described, followed by the results of the fluid-bed testing program. The last section of the final report is a presentation of the systems study showing the performance and economics of a fluid-bed, municipal-solid-waste combustion system which incorporates electrical power generation with process heating.

Proposed System

In order to prevent the present study from becoming merely an academic exercise, a practical possible application was defined so that the experimental program would be conducted under realistic test conditions and the economic study would have reference to a specific situation. Therefore, consideration was given to the energy requirements of Stanford University. This is a particularly favorable situation, inasmuch as the University has a central steam-heating system and an electrical power requirement. At the present time the electrical power is supplied by the local utility, and steam is generated in the University's boiler system with natural gas as the fuel, backed up by light fuel oil. The balance of the heating and electrical load is such that co-generation of electricity and process heat is feasible and very attractive from a technical point of view.

The general concept for the Stanford Solid-Waste Energy Program (SSWEP) is to process solid waste at a convenient collection site, where some landfill is available to handle the non-combustible part of the stream. The lightly processed solid waste, which would be processed only so that it can be fed into the combustors through a 5"-diameter pipe, would be transferred to the University campus with special transfer trucks. The size of the system is specified by the available Municipal Solid Waste (MSW), which is estimated to be 800 tons of processed MSW per day in 1983. This corresponds to approximately 1200 tons per day of raw MSW delivered to the remote processing site. The plan would be to feed the processed MSW to fluid-bed boilers which would be built in a modular fashion for economy and for improved turn-down as required for meeting the variable load on the campus. Superheated steam at a modest pressure and temperature would be delivered to a steam turbine, with extraction at a pressure of approximately 170 psia. The extraction steam would condense in a heat exchanger and then be returned to the fluid-bed boiler. The heat exchanger would transfer heat to the return condensate from the Stanford heating system to produce 140 psia steam for the Stanford system. If all of the flow from the high-pressure turbine was not required for the heat exchanger, the remainder would flow to a condensing turbine in order to generate more electrical power. A cooling tower would be provided for cooling the condenser so that the fluid-bed boiler steam would be self-contained and could be carefully controlled.

The fluid-bed boiler system involves a combustion air blower, an air preheater, and an exhaust clean-up system after the fluid-bed boiler. The solid waste would be introduced into the bed pneumatically, and the present design incorporates internal recycling of elutriated flyash and bed material to the bed, as this was found beneficial in the experimental program. Most of the system is conventional, with the fluid-bed boiler being the most novel and at the same time the most critical component. Because of this, an experimental program was performed in a 7 ft^2 fluid-bed combustor with water-cooled tubes. Air-cooled tubes were included for corrosion tests in both the freeboard and in the active bed, in which test samples were subjected to the expected temperature of superheater tubes in an actual application.

Test Results

Two 50-hour runs were made to check out the system and to determine a satisfactory operating point for the principal experiment of 300 hours' duration. The test conditions were:

superficial velocity = 4.5 ft/sec
bed temperature = 400 F
freeboard temperature = 1500 F
excess air = 44%
internal recycle of elutriated solids to bed

The 300-hour test was performed without incident and terminated on schedule. The combustor and ducting were clean on inspection after the test, and bed agglomeration did not occur. A corrosion-erosion tube placed in the freeboard showed considerable metal wastage for carbon and low-alloy steels and some wastage for stainless steels. Low-temperature carbon-steel water tubes in the bed showed negligible wastage. It was concluded that heat-exchanger tubes in the freeboard require protection from the high-velocity elutriated solids. Combustion efficiency was greater than 99%, and pollutants were measured as follows:

SO_2	58	ppm
NO_x	178	ppm
CO	242	ppm
Hydrocarbons	4.4	ppm

Economic Summary

The material from the cost estimates described in the final report is summarized in Table 1. Each major subsystem is shown, along with the additional costs which are recommended for a construction project such as this by the standards of the Electrical Power Research Institute. The total direct cost as estimated is 16.7 million dollars, and the total plant investment, using various contingencies and sales tax, amounts to $23.1 million. This figure should be compared to plants which handle 1200 tons per day of raw municipal solid waste and produce both steam and electrical power. The costs presented do not include processing or transporting the processed MSW to the point of use.

Table 1. *Stanford Solid-Waste Energy Program: Total Plant Investment*

1.	*Boiler system*	$ 2,239,700
2.	*Startup system*	155,200
3.	*Combustion air system*	798,900
4.	*Flue-gas system*	2,382,000
5.	*Bed-maintenance system*	84,100
6.	*Flyash-disposal system*	79,200
7.	*Fuel-feed system*	457,800
8.	*Fuel-receiving bldg., equipment*	252,400
9.	*Main steam system*	5,421,000
10.	*Feedwater system*	1,942,600
11.	*Electrical/controls/misc.*	1,204,100
12.	*Building, sitework, construction, A & E*	1,645,000
	Total Direct Costs	16,662,000
	Undistributed Costs (6%)	999,700
	Process Capital	17,661,700
	Engineering & Home Office Fees	1,666,700

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Michael I. Black *is the EPA Project Officer (see below).*
The complete report, entitled "Investigation of Fluid Bed Combustion of Municipal Solid Waste," (Order No. PB 85-242 121/AS; Cost: $11.95, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

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