COMBUSTION OF SCRAP OIL FOR STEAM GENERATION

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ABSTRACT

A program was undertaken at Westinghouse Industrial Ceramics Division to investigate the economic and technical feasibility of using waste oils as supplemental fuels for their process and heating steam boilers. A large portion (~ 8 percent) of the division's gross sales is being spent on natural gas and oil to fire the boilers. Since a high quality scrap oil could be obtained at a lower cost per million Btu's than the lowest cost conventional fuel (natural gas), modification of the existing boiler fuel system to accommodate waste oils appeared economically attractive.

In order to insure that the waste oil is free from water and particulates, proposals for a fuel cleanup system were obtained. A $300 system was selected and installed and has performed admirably with appreciable savings in fuel costs.

Westinghouse is continuing to evaluate other candidate waste streams as boiler fuels. Inginable solvents are not economically attractive because of stringent regulations that make firing of scrap solvents too costly. Non-oil scrap liquids that have been found to be attractive are non-hazardous liquids with heating values and viscosities approaching No. 2 oil.

INTRODUCTION

This paper describes our experience in using scrap liquids as boiler fuel during the past year. The idea makes sense, the procedure is simple, and the benefits are appreciable. We describe our ideas, goals, attempts, experience, and results.

INCENTIVE FOR FIRING SCRAP LIQUIDS

In the process of surveying energy requirements and waste generation at Westinghouse plants it was determined that large quantities of a "clean" oil were being sold to scrap oil dealers at a price of 10 to 20¢/gal. The oils were clean in that the level of contamination was below the threshold for hazardous waste. Although the oils are of high quality and clean, Westinghouse does not act as a fuel blender serving the open market, but disposes of scrap oil through proper dealers.

The survey also spotlighted the fact that the Westinghouse Industrial Ceramics Division at Derry, Pennsylvania applies a large portion of its gross sales dollars to energy costs. Forty-seven percent of the site's energy usage is for kiln-firing and glazing of their product. The remaining 53 percent of the energy usage is for process steam required for humidity control in dryers and for space heating.

It made sense to us to use scrap fuel where it was needed: the resource value of the waste could be reclaimed and fuel purchases could be trimmed.

PROGRAM OBJECTIVES

Our overall objective in this study was to supply a part of the Ceramics Division's energy needs with scrap energy resources. Particular objectives were to:

(1) Identify Burnable Waste. These include scrap liquids from Westinghouse operations as well as liquid burnables from other sources.

(2) Design a safe working system. A safe working system will provide a safe working environment, maintain emissions below regulated thresholds, and not subject the
boiler equipment to corrosive, erosive, or fouling feedstocks.

(3) Collaborate where necessary with regulatory agencies. Use of waste burnable liquids as fuels is not new and the literature contains isolated descriptions of similar systems [1-5]. The abundance of cheap conventional fuels in the past provided little incentive for energy recovery from waste liquids. Today many scrap burnables are recovered as blending stocks. We concluded that the greatest dollar savings would come from replacing natural gas (which is equivalent in price at this location to number 2 oil at 67¢/gal) with scrap fuel, as opposed to selling scrap oil for blending stock at - 20¢/gal or attempting to assure number 2 oil characteristics and serve as an oil dealer.

DESCRIPTION OF THE BOILER FACILITY

The Westinghouse Ceramics Division at Derry, PA has four boilers.

Since the Clayton boilers are designed to fire a variety of fuels and are forgiving of extremes in vapor pressure and viscosity, they were identified as the process boilers in which scrap fuel will be utilized. The individual boilers operate at a full capacity flowrate of 74 gal/hr and 5 percent oxygen in the stack.

A photograph of the Model E300 Clayton boilers can be seen in Fig. 1, and the respective flow schematic in Fig. 2. Four 20,000 gal storage tanks are used to store liquid fuels for the boilers, and one of the four has been isolated for scrap oil. These tanks gravity feed the boiler fuel pump, and the pump pressurizes the fuel supply line, from which the boiler fuel is throttled. In cold weather, a hot water heater keeps the oil temperature above 20°F so that the flow through the filters can be maintained.

SCRAP OIL AS FUEL

SELECTION OF A SCRAP-OIL FIRING SYSTEM

A preliminary proposal was made to the Industrial Ceramics Division in which waste oils would be used as a supplemental fuel for their steam boilers (See Fig. 3). Waste oil would be metered into the primary fuel feed line at a location upstream of the burner. The amount of waste oil that would be metered into the primary fuel would vary with the quality of the oil, with a high Btu oil comprising larger percentages of the boiler fuel than a lower Btu oil.

The oil that would be stored in the tank would have to be free of particulate matter and water. Particulate matter can lead to severe erosion in the pump and nozzle, and water can slug and result in flameout in the burner or freezing of the fuel system in the winter months. Therefore, we began working with a local resource recovery firm to expand our initial concept. This firm proposed a sophisticated system with a price tag of $225,000 which was optimized and reworked to result in the $88,500 system shown in Fig. 4.

In parallel with this effort a filter representative was contacted for proposals. He recommended a more simplified treatment system (Fig. 5) at a total cost of $7800.

The filter representative further suggested that the above system was overly conservative and that a simple removal of any layered water followed by filtration would work just as well (Fig. 6).

There was unanimous agreement amongst our plant and planning personnel to install this system because of the high potential savings with low risks. The system (See Fig. 7), consisting of a Wilden diaphragm pump and a Keene pleated paper filter, was installed and operating in two weeks at a total capital and installation cost of $300.
WASTE FUEL ANALYSIS

The oils that were considered for supplemental firing of the boilers are designated as scrap oils. Table 2 lists the ultimate analysis and heating value of the transformer oil that was used in the program and the base No. 2 oil that is the primary liquid fuel at the boiler facility. The chlorine, sulfur, and nitrogen content of the scrap oil is comparable to the No. 2 and is well within acceptable limits for a primary boiler fuel. The carbon and hydrogen are essentially in the same concentrations in both oils, resulting in less than 1 percent difference in their higher heating values.
Scrap Oil → Motionless Mixer → Paper Roll Filter

High Density Polyethylene Polymer

Oil with < 50 ppm Water to Boilers

1500-Gallon Heated Conical Separator

Solids and Paper to Landfill

Water to Disposal

FIG. 4 EXPANDED CONCEPT WASTE-OIL FUEL SYSTEM

Air Supply

Controller

Heaters

Reservoir

From Tank Truck

To Storage Tank

Water Sight Gauge

Coalescer

Water Drain

FIG. 5 FILTER AND COALESCER CLEANUP SYSTEM

TABLE 2 ANALYSIS OF LIQUID FUELS

<table>
<thead>
<tr>
<th>Ultimate Analysis (%)</th>
<th>Scrap oil</th>
<th>No. 2 oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.01</td>
<td>0</td>
</tr>
<tr>
<td>S</td>
<td>0.07</td>
<td>0.19</td>
</tr>
<tr>
<td>Cl</td>
<td>86.71</td>
<td>86.83</td>
</tr>
<tr>
<td>H</td>
<td>13.09</td>
<td>12.88</td>
</tr>
<tr>
<td>N</td>
<td>0.07</td>
<td>0.00</td>
</tr>
<tr>
<td>O</td>
<td>0.05</td>
<td>0.10</td>
</tr>
<tr>
<td>HHV (Btu/lb) (MJ/kg)</td>
<td>19605</td>
<td>19520</td>
</tr>
<tr>
<td></td>
<td>45.4</td>
<td>45.6</td>
</tr>
</tbody>
</table>

LABORATORY COMBUSTION TESTS

Samples of the scrap oil were obtained so that its combustibility could be evaluated in a laboratory environment, prior to use in the process boilers. Short duration tests were run on both the scrap oil and No. 2 fuel oil so that a direct comparison of combustion efficiency could be obtained.

The test facility is shown in Fig. 8. Oil is gravity fed into a fuel pump, pressurized, and throttled to the air-assist burner nozzle. A gun-type swirl burner mixes ambient air with the fuel and ignites the mixture. The gun fires into a
measured in a Beckman flame ionization instrument. Nitric oxide concentrations are measured in a Thermoelectron NO/NO\textsubscript{x} chemiluminescence meter.

The results of test firing the oils can be seen in Table 3. The burner was run with high excess air and thus low CO\textsubscript{2} levels in the stack gases. The higher temperature that resulted from the combustion of the scrap oil was due to the somewhat lesser excess air and the increased temperature of the furnace environment with time. This would also explain the increase in NO concentration, but basically there is no significant difference in performance when using the two oils.

Since the scrap oil in this case was being considered as a primary fuel for the boilers, we performed another basic test in the laboratory. Whereas the ignition of the burner for the combustion tests was done on No. 2 oil, ignition of the burner in the warm and cold state was also done with the scrap oil. Ignition of the burner in both cases was immediate with stable combustion.

**OPERATING EXPERIENCE**

Ongoing Westinghouse Experience has shown that using scrap oil as a boiler fuel is economically favorable.
During November 1982, the first month of operation, 70,000 gal of scrap oil was fired at a savings of

\[
\begin{align*}
\text{70,000 gal} & \quad (\$0.60 - \$0.20 - 0.10) \\
& \quad \text{scrap oil equivalent oil cost per gallon oil value} \\
& \quad \text{transportation cost}
\end{align*}
\]

= $21,000

The system has been in operation for one year on both bulk and drummed scrap oil.

**EFFORTS TO FIRE SCRAP SOLVENTS AS FUEL**

In identifying scrap fuel sources we discovered that there are appreciable quantities of scrap solvents that would serve as boiler fuels if admixed with conventional fuel oil (either no. 2 or reclaimed scrap oil). Experience has indicated that a mixture of 75:25 oil: other fuel is generally equivalent to pure oil and that for a more conservative 90:10 mixture, firing characteristics are virtually unchanged.

Our inquiries identified sources of scrap methanol, acetone, mineral spirits, and isopropyl biphenyl that are available for between 6 and 15¢/gal. Our technical strategy was to filter scrap solvents and feed them into a dedicated storage tank as shown in Fig. 6. From storage, the solvents would be admixed with fuel oil through a metering pump and motionless mixer as shown in Fig. 3. Savings from such a use of reclaimed energy would be appreciable considering the charges required for disposal of ignitable (and, therefore hazardous) wastes.

The next step in the process was to meet with those officials who regulate emissions, hazardous wastes, and use of nonconventional fuels. The result of our meeting in August, 1983 provided a go-ahead requiring application for RCRA Part B status as a storer. The dollar savings did not sufficiently exceed the costs in manpower and equipment to fulfill the requirements to:
• prepare an air quality plan
• gain approval of record keeping plans, sample storage plans, an analysis plan, and a Pollution Prevention and Control Plan
• gain approval of proposed tank installations
• install monitoring equipment and assure continuous monitoring of flue gas oxygen and temperature
• conduct quarterly inspection tours, and
• provide flue gas analyses

Therefore, we chose to abandon plans for using scrap solvents (ignitable hazardous waste) as boiler fuel. Of course, this economic analysis and the resulting decision is determined by the cost of energy at the Division. An upward change in the cost of natural gas and/or fuel oil will result in a greater net difference between the solvent and feed cost and a substantial potential savings if solvents are used to supplement the standard fuel. Therefore, if the cost of energy increases at the division, this program will be reconsidered.

ACKNOWLEDGMENT

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REFERENCES


Key Words: Boiler • Combustion • Energy • Fuel • Recycling • Scraps • Waste Control