CONSIDERATIONS REGARDING INCINERATION OF
INDUSTRIAL PLASTIC AND HAZARDOUS WASTE:
A CASE STUDY

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Discussion by

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The author properly concludes that on-site incineration of industrial plant waste, including highly chlorinated plastics and hazardous wastes, is technically and environmentally viable, but the decision that must be made is whether its cost is justified.

There are risks and uncertainties in implementing an incineration energy recovery concept as there is in continuation of landfilling.

Table 6 pro forma costs for the "best case" scenario is used by the author to illustrate the potential economic attractiveness of the recommended incineration energy recovery concept. The data presented may be critically analyzed for sensitivity to variations in cost predictions.

Operating and maintenance costs are always a subject of conjecture.

The $300,000 estimate for these costs may be inadequate. The allowance for maintenance, including renewal and replacements expenses, is suspect, since there is so little field experience upon which to base this estimate.

The proposed business arrangement whereby the selected vendor will design, construct, start up, and acceptance test the incinerator and operate the incineration/heat recovery system for but one year, may not be satisfactory. This is because major maintenance costs and the expenses of renewal and replacements would more likely occur after the one year period has run its course, at which time the vendor is no longer responsible for operating and maintenance costs. Accordingly, a three or four year period for vendor operation and maintenance of the facility may be more appropriate. It would be of interest to have the vendor re-submit his annual cost projections based on a three or four year operating and maintenance contract.

The author states residue disposal costs are neglected, as are apparently the disposal cost of by-passed waste material. These costs can be appreciable and may adversely impact overall project economics. Several issues need to be resolved in order to properly assess these costs.

Hazardous/non-hazardous classification of the residue requires definition. This is a function of the degree of destruction of the organic waste fraction, the resultant concentration of toxic heavy metals in the residue, and fixed carbon (char) in the residue. The char in the residue may serve beneficially to adsorb the heavy metals to prevent their leaching, especially in a high pH medium which characterizes the ash quench water. If an EPA Extraction Procedure (EP) test causes the residue to be classified hazardous, additional costs will be incurred in its disposal.

Many of the vendors offer test burn facilities. A comprehensive test burn program is recommended to characterize the residue that would need to be disposed in a landfill and also the effluent gas that would require clarification before discharge to atmosphere.

Another issue that needs to be resolved is the allowable bypass waste to landfill. This bypassed waste could range from 15% to 40% of the available waste stream and would impact overall project economics.

Bypass waste to landfill can be minimized by redundancy in incinerator plant design and by provisions for stock-piling waste in the event of outages. Of course, capital costs would increase and overall economics affected thereby.
The driving force that makes the incinerator energy recovery project economically attractive and ultimately justifies the risk of project implementation is the considerable savings that is possible in the manufacturer's plant annual cost for purchased fossil fuel (oil and/or gas) and possibly electricity.

The case example illustration given by the author provides data that allows the energy available in the waste material to be calculated as 219,000 x 10^6 Btu per year. On the face of it, this compares favorably with the 330,000 x 10^6 Btu energy content of fossil fuel used in 1981, since it appears all of the energy available in the waste material may be beneficially utilized.

Although the waste fuel available/fossil fuel use correlation on an annual basis appears satisfactory, it is necessary to perform a further check on the energy use profile. This is done on a seasonal and even on hourly basis to assure that the waste-derived energy is beneficially utilized. Although such a check may have been performed, no mention is made of it in the author's narrative.

For example, a 2-shift, 5-day per week operation schedule at the manufacturing plant would necessitate a different mode for incinerator operations than would a 3-shift, 7-day per week manufacturing plant schedule and may in fact drastically affect project economic viability. The steam turbine generator addition affords some flexibility in energy use, since electricity generated from waste in excess of the manufacturing plant's requirements at any time, may be sold to the electric utility. In this respect, it would be of interest to know whether the steam turbine generator selected is of the condensing or non-condensing (back pressure) variety.

This discusser recognizes that the subject of energy profile matching could be a subject of considerable length and would probably warrant a separate paper in a future ASME Proceedings. The subject is at least worth mentioning here, since it could strongly impact overall project economics.

Discussion by

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This paper is a theoretical feasibility study of a project that would produce energy from incinerating a small quantity (22.7 TPD) of industrial waste. The waste is estimated to be 95% solids and 5% liquids by weight. Of the liquids a fraction could be classified by EPA as hazardous. The system would operate seven days a week, 24 hr a day with a total O & M budget of $300,000 per year (absolute minimum labor staff). The system was planned to produce steam for direct use by the industrial plant supplying the waste, while simultaneously co-generating electric power for use by the same plant.

The problem with this study is that it ignores the first step that is necessary in planning such a system and determining whether it is feasible. After obtaining "sales" information from various vendors of furnace technologies, there is no attempt to perform the necessary design criteria calculations, and most importantly, to develop the required mass and energy balance calculations. As a result, all calculations become "pie in the sky" offerings to the prospective energy user and plant investor. Such calculations could have been made for each technology being considered, or the consultant could have selected one of the technologies, that he considered to be the optimum, and then made accurate calculations around it. To leave out as many important calculations as seen by the resultant report is a disservice to a client.

As examples of this, we note that the industrial plant has need for 30,000 lb/hr of steam. With the firing of the waste as described and in a mass burning furnace, we calculate that the most efficient furnace boiler combination might produce a constant of 5290 lb/hr of low pressure (200 psig) steam, from which must be deducted about 15% per year for off-line maintenance, both preventive and corrective. Yet the consultant claims that the system will replace 100% of the fuel oil and 50% of the propane being used by the manufacturing plant.

There is proposed the installation of a 1 MW turbine generator set to produce 2 million kW of electric power per year. If a straight condensing turbine is used, and if steam is generated at minimum 450 psig and 600°F, and if a relatively sophisticated and complete mini-electric power plant is designed and installed, slightly over 3 million kW of electric power could be produced. With 65% availability the 2 million figure could be reached. However, electric power production is apparently secondary. Plant steam production is the primary purpose. This infers an extraction turbine and lower power production.

An analysis of the study raises many further questions. First, why is electric power production being considered in any way? The plant supposedly can have a pay back period of only 3.4 years. By all calculations the pay back on the electric power add-on is more in the neighborhood of 12 years.

Second, why would the manufacturing plant in permitting the system run the risk of being classified as a hazardous disposal site? The vast majority of the waste is classified as non-hazardous in any state. The small quantity of liquid waste that is classified as "hazardous" could be disposed of inexpensively.

Third, why has the consultant ignored the lessons that have been learned over the past six years concerning the
"dilution factor" in the incineration of industrial waste for the production of some form of energy? The most efficient incineration method is to incinerate common industrial waste (such as the paper describes) in combination with residential and commercial waste, normally at a ratio of no more than 7% chlorinated plastics and high heat liquids to 93% mixed residential and commercial waste. This achieves the "dilution factor" on the problem industrial segment and largely eliminates the side effects experienced problems of corrosion in the equipment, in the "dilution factor" in the incineration of industrial waste with residential and commercial waste, normally at a ratio of no more than 7% chlorinated plastics and high heat liquids to 93% mixed residential and commercial waste. This achieves the "dilution factor" on the problem industrial segment and largely eliminates the side effects that could happen as the paper describes. Apparently no consideration was given to this by the consultant in advising the client.

The dilution factor has been observed and studied carefully in at least four controlled-air, mass burning plants, that use the two stage combustion process. These plants are municipal waste to energy facilities. They range from 200-300 TPD in design capacity. They average as high as 20-25 TPD of industrial waste of almost the exact breakdown described in the study. This is common in several cities having an industrial base. These plants have not experienced problems of corrosion in the equipment, in the air and water emissions, or in the ash produced. None of them have installed scrubbing devices (such as mentioned in the study). The main change in technology is that the latest designs all incorporate a properly designed and constructed baghouse system, rather than precipitators.

The dilution factor has ensured that the plastics and other problem components are diluted both in the fire and the effluent gases to the boilers and the APC/stack assemblies. The concentrated effect is eliminated. One surprising result has been that gas leaving the new concept in baghouse design is neutral and even alkaline in structure, rather than acid as described in the study, despite high quantities of chlorinated plastics in the waste stream. Obviously technology is important. With two stage burning at low oxygen and fire temperature in the primary and high oxidizing with 2000-2200°F emerging from the secondary there are considerable chemical changes in the fuel, which effect the results.

AUTHOR'S REPLY

I would like to thank both reviewers, Mr. Roger Burns of Hyden-Wegman, Inc., and Mr. Ross Hoffman, for their comments. I will respond to each reviewer's comments separately.

To Roger Burns

In response to the third, fourth and fifth paragraphs, the author agrees with the fact that operating and maintenance (O&M) costs are uncertain because of a lack of substantial equipment operating experience. However, the $300,000 estimate does fall within the range of estimates CSI developed and within those presented by several interviewed vendors who have had operating experience, although limited. In any case, the economic analysis was meant to illustrate that even under the best of circumstances — low capital and O&M estimates — installation and operation of an on-site incineration system as proposed is not inexpensive. A refined economic analysis, including variations in capital and O&M cost estimates, is needed to evaluate the sensitivity of the results to these different inputs.

Concerning the sixth paragraph, the author agrees with this comment. The one-year operating requirement was a minimum requirement specified by the client. A longer operating requirement might very well be desired by the client in the future and will be further evaluated during project development.

In reply to paragraphs seven through nine, the author agrees with these comments. Test burns have been recommended and will be conducted if project development continues.

In relation to paragraphs ten and eleven, waste will not be bypassed to a landfill. All the waste is processable. The facility design will provide for both adequate storage for waste prior to incineration and an adequate incinerator size to accommodate variations in waste generation and equipment downtime.

The author agrees with the remaining paragraphs. Analysis of waste fuel availability/fossil fuel demand has been conducted preliminarily on an hourly and seasonal basis. A more refined analysis is necessary and must be performed during project development to finalize system sizing to further assure that the waste availability and energy demands match and that project economics are viable. One of the primary reasons for developing a cogeneration system was to provide a means of effectively utilizing the energy derived from the waste when the fossil steam demand was low.

Options for utilizing both an extracting condensing and a back-pressure turbine were evaluated. The case illustrated in the paper is for the back-pressure turbine.

To Ross E. Hoffman

Concerning paragraphs one through three, although not provided in the paper, mass and energy balances were developed during the feasibility study to evaluate several options for matching waste availability and plant energy demands. The case selected for illustration in the paper is for a cogeneration system with a back-pressure turbine. Vendor "sales" information generally confirmed our
analyses. It was not the sole basis for our recommenda-
tions.

As indicated by the previous comments by Mr. Roger
Burns, the waste fuel availability/fossil fuel demand are
compatible. Apparently, Mr. Hoffman failed to note that
the higher heating value of the fuel is 12,000 Btu/lb, not
4500 Btu/lb as is common in municipal waste. When pro-
cessing 25 TPD of this waste, the heat input is approxi-
mately 25 MBtu/hr. If producing a 200 psig saturated
steam, this heat input is equivalent to approximately
15,000 lb of steam per hour, assuming 60% efficiency of
the boiler, not 5290 lb/hr as Mr. Hoffman calculates.

In regard to plant energy demand, Mr. Hoffman is
incorrect. Although the present plant boiler capacity is
30,000 lb/hr of steam, present use for peak steam demand
is on the order of 15,000-20,000 lb/hr and average annual
steam demand is on the order of 8,000-10,000 lb/hr.

Consequently, the assumptions are presented in the
paper are correct.

In reply to the rest of Mr. Hoffman’s discussion, elec-
tric power production is considered to provide a means of
effectively utilizing the energy produced from burning
the waste when the plant steam demand is lower than the
proposed incineration facility’s output. Plant steam de-
mand fluctuates on an hourly and a seasonal basis and is
often below the incineration facilities output.

The economic evaluation determined that the system
payback for the cogeneration system, including turbine
generator, was 3.4 years. The payback on the turbine
generator itself was 2.8 years, indicating that the addition
of the turbine generator improved the overall system eco-
nomics. I do not understand the basis for Mr. Hoffman’s
12-year payback for the electric power add-on.

In regard as to why the client desired to incinerate
their hazardous waste, it is primarily one of concern for
potential liability for continued landfilling.

In regard to use of the “dilution factor” at other in-
cineration facilities, such municipal waste facilities cannot
legally accept hazardous waste unless they are permitted
to do so. No such facilities exist in New England.

Currently, the plant is disposing a portion of its non-
hazardous waste at existing municipal waste-to-energy
facilities and the remainder at landfills. It is not inexpen-
sive.

In addition, the intent of the study was to evaluate the
potential for on-site incineration of all plant waste such
that the client has complete control of its wastes and their
ultimate disposal. The client himself is in the process of
evaluating other potential disposal alternatives.