PNL-SA--18729

DE91 002551

AN ANALYSIS OF THE COMMERCIALIZATION OF EIGHT CONSERVATION TECHNOLOGIES

S. A. Smith
A. G. Thurman
S. E. Grover

October 1990

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

INTRODUCTION

The Office of Industrial Programs (OIP) has a long history of developing commercially successful technologies. This success is based on OIP's efforts to involve industry early in the technology development process and on the use of highly skilled technical staff. However, even the most technically successful products can fail to achieve widespread market acceptance. The objective of this work is to determine why some OIP-sponsored technologies are not being commercialized and to determine what OIP can do to promote commercial acceptance.

OIP technologies evaluated in this study included

- Extraction of Organics from Water
- Fuel-cell Membrane
- Fused Salt Catalyst
- Industrial Humidity Sensor
- Kiln Dust/Fly Ash
- Machnozzle
- Membrane for Solvent Recovery
- Spectral Flame Analyzer.

Each technology evaluation began by gathering the appropriate technical reports, contacting the OIP technical monitor, and interviewing OIP contractors. A copy of the interview script has been included as an Appendix A to this report; source material and contacts are listed in Appendix B.

The results of each telephone interview were documented on PNL contact sheets and summarized for this report. After reviewing these summaries, PNL staff made specific recommendations for each technology.

CONCLUSIONS

A review of all eight case studies revealed some common elements. In general, most of the technologies proved to be technically sound, and the main barriers to acceptance were market-related rather than technical.

- Large companies can lose interest in developing some technologies if the potential market is too small (relative to company standards). Smaller, specialized companies are likely to have the motivation to continue developing the technology, but frequently lack the capability to successfully market the technology.
- Looking beyond the original technology application will help to identify additional market niches for the technology. Many first markets (i.e., entry markets) are not the ultimate market for the technology, but they allow the developer to test and refine the idea in a real-world application.
- Successful introduction into the market requires that a technology meet a particular market need and that the technology be sound. Some companies have excellent technical capabilities while others excel at marketing. Identifying marketing shortcomings before the research effort begins will allow the organization the opportunity to strengthen these areas.
- Ideas that are technically sound can still have difficulty making it into the marketplace, particularly when market conditions are unfavorable (e.g., relatively low energy prices). A means of archiving the technology needs to be established. The archiving method should preserve technical knowledge gathered to date and allow periodic reviews of the technology to determine if market conditions have sufficiently improved.

RECOMMENDATIONS

The recommendations address methods DOE could use in dealing with the market issues identified above.

- Extraction of Organics from Water

  This technology is commercialized, and no additional assistance is required.

- Fuel-cell Membrane

  Provide minimum funding to establish a shared-savings demonstration with the chlor-alkali industry.

- Fused Salt Catalyst

  Develop information brochures to be distributed to appropriate innovative companies that would be willing to use the technology. As the relative price of energy increases, interest in this technology will also increase.

- Industrial Humidity Sensor

  Suggest to Honeywell that the technology be licensed to a smaller company interested in marketing the technology. Provide funding for development of a self-cleaning feature and market to the grain-drying industry; market the current technology to non-agricultural industries.

- Kiln Dust/Fly Ash

  Focus on development of the technology as a means of converting solid wastes into fertilizer. Could encourage funding from DOE-EM to help support development. Address environmental concerns before considering use as a paving compound.

- Machnozzle

  Investigate using the technology on other problems such as heavy fabrics and on problems outside the textile industry.

- Membrane for Solvent Recovery (from air)

  Focus on smaller, more specialized market niche and provide funding for membrane demonstrations.

- Spectral Flame Analyzer

  Because of the expense of developing an algorithm for the system, it is not worthwhile to pursue the development of this technology at this time. However, it may be worthwhile to try to identify additional applications for the existing sensor.

EXTRACTION OF ORGANICS FROM WATER

A common practice in the chemical industry is the extraction of organic chemicals from water. The primary method for removing organics from water has been distillation, a very energy-intensive technique. Organic compounds can also be separated by a liquid-liquid extraction process in which the compound is washed out by a third liquid component, a solvent. However, the compound must then be removed from the solvent, which is itself an extraction process. This second extraction can be avoided by using a critical fluid for the liquid-liquid extraction. With physical properties somewhere between its gas and liquid forms, the critical fluid removes the organic from the water. The critical fluid is then removed from the compound by returning the critical fluid to its gaseous state.

Critical Fluid (CF) Systems developed a technology which extracts organics from water using a condensed carbon dioxide solvent. The extraction process is more energy efficient than current distillation techniques. Critical fluid extraction has been tested at the pilot plant scale. The objectives of this part of the project were to demonstrate the feasibility of this technology and to gather the engineering data required to evaluate the process. Further experimentation, refinement of equipment and procedures, and process modifications were recommended.

MARKET-RELATED ISSUES

CF Systems has built three commercial units to date. One was built as a pretreatment step for a solids incinerator. Another was built to extract organics from a wastewater stream (20 GPM) at a treatment, storage, and disposal (TSD) facility in Baltimore, Maryland. The third unit was built to extract organics from sludge and soils (50 tons per day). This unit is currently operating at the Star Enterprise (Texaco) refinery in Port Arthur, Texas.

In addition, the company has a demonstration unit that has been operating for the past two years at a number of refinery sites in the United States and Canada. The unit recently was operating at the Ashland refinery in Catlettsburg, Kentucky, and is now at the Texaco refinery in Port Arthur, Texas.

A pilot-scale unit was evaluated by the Environmental Protection Agency's (EPA) Superfund Innovative Technology Evaluation (SITE) program, which was designed to validate or reject manufacturers' claims on new technologies. Specifically, CF Systems' technology was successfully demonstrated by extracting polychlorinated biphenyls (PCBs) from harbor sediments in New Bedford, Massachusetts. Although the EPA project manager at the time felt that the technology did a good job of extracting the PCBs from the harbor sediment, he pointed out that the success of the technology is difficult to define. How well a technology can extract organics from 20 barrels of feed per day (as a pilot unit) is different than its performance on 200 barrels per day (as a commercial unit).

EPA Region VI also used the demonstration unit at a Superfund site in Conroe, Texas, to remove creosote and pentachlorophenol type compounds from a wood treating waste site. The demonstration was an unqualified success, and CF Systems is specified in the Record of Decision (ROD).

Nine patents, stemming from the initial work, have been issued; however, the technology has not been licensed. The technology has been used primarily in waste remediation applications. The EPA has designated the technology as the best demonstrated available technology (BDAT) for Resource, Conservation, and Recovery Act (RCRA) refinery waste series, KO48 - KO52.

According to a CF Systems marketing representative, numerous formal market activities have been conducted. The market for the technology is a typical industrial market: small and specialized. Although formal activities such as direct mail and advertising have been successful, significant effort has been directed toward talking with people in the industry. About 100 refineries make up the market, with the major companies composing about 70 percent of the market.

The marketing manager attributes low sales to the slow pace of remediation activities. He contends that engineering and risk analysis work in hazardous waste has been growing, and the remediation side is just beginning to "roll out." Although sales are not as large as desired, he feels sales will increase when remediation becomes more in demand. CF Systems uses its own sales force, which comprises a small group of engineers who talk to people in the industry. Only two CF Systems employees are currently selling this technology.

Competing technologies include centrifuges, solvent extraction technologies using biotechnology or ultra-violet treatment, incineration and land fill. One advantage of CF Systems' technology is that it has been commercialized; whereas, other solvent extraction technologies have not. Other advantages are its low operating costs and its simplicity. Because of the stringency of hazardous waste regulations, this technology is more suitable to remediation than some others such as centrifuges.

CF Systems soon will be bought by Morrison Knudsen; CF Systems will recommend that research into this technology be continued. According to the EPA contact, Morrison Knudsen's purchase of CF Systems has contributed to the lag in commercializing the technology. He predicts that once the transaction is complete, more money will be available to commercialize this technology. CF Systems feels that more effort should be put into the original intent of the research, which was to look at the technology's energy-saving features and to analyze it as a first alternative to distillation. (This initial effort was changed because of the market opportunities that overtook CF Systems in the hazardous waste area.) The effort should focus on two areas: 1) waste treatment in the chemical process industry and 2) reuse of solvents in the chemical industry such as pharmaceutical companies.

The EPA SITE project manager feels the money for this project has been well spent. CF Systems has gone farther with this technology in marketing and technical development than other companies have with other solvent extraction technologies. He has a good feeling about the technology--the timing is right. He feels the federal administration is changing its attitude by tolerating more risks with new technologies. In the past, he said, lawyers dominated Superfund and risk was to be avoided. Therefore, incineration was the chosen method for dealing with hazardous wastes. The current administration is taking more of a chance with new technologies.

RECOMMENDATIONS

No additional work is required.

Future expansion of the technology will depend on the amount of remediation work initiated over the next several years and the success of CF Systems' promotional activities.

FUEL CELL MEMBRANE

The chlor-alkali industry manufactures chlorine and caustic soda in a process that requires large quantities of both electrical and thermal energy. Efficient use of or elimination of the hydrogen by-product would greatly reduce industrial energy use. From 1987 to 1989, Physical Sciences, Inc. (PSI) worked to develop various fuel cell concepts for a more efficient process.

The four fuel cells that were tested were an H_2-Cl_2 fuel cell (HCLFC), an electrochemical concentrator (ECC), an alkaline H_2-O_2 fuel cell (AFC) and an air depolarized chlor-alkali cell (ADCAC). PSI is working on developing the electrocatalysts and electrode technologies for these processes. The HCLFC consumes some of the by-products of hydrogen and produces electricity, as do the ECC and the AFC processes. The ECC also concentrates the caustic soda to 50 wt% and eliminates the need for thermal evaporation.

MARKET-RELATED ISSUES

The ECC technology has proved to be effective and reliable and would provide a 20% energy savings over current technology. However, to date, the technology has not been sold, nor has it been licensed. The major obstacle preventing wide-scale commercial use of the technology is the relatively high capital costs. Because no sales have been made to date, uncertainty also surrounds any capital cost estimates. The capital costs could be reduced by decreasing the amount of platinum in the electrodes, reducing the membrane cost, and by demonstrating long life operation of these electrodes and membranes.

Several firms, including Dow, DuPont, Pittsburgh Plate Glass, and Occidental Petroleum, were contacted to see if they were interested in a cost-sharing program to test these fuel cells in actual applications. These companies were reluctant to participate because of uncertainty surrounding the costs and the fact that the technology has not been tested in a plant-scale, chlor-alkali setting.

The Japanese Soda Industry Association has expressed interest in the technology and is paying PSI to conduct some small feasibility studies. These studies will help to determine if the technology is applicable to the Japanese chlor-alkali industry. If the tests are successful, the technology will be licensed by the Japanese. PSI will retain rights to market and license the technology in North America. Licensing rights for European sales will be negotiated at a later date.

RECOMMENDATIONS

Support the installation of the technology in a domestic plant.

Sparking the interest of the chlor-alkali industry in an energy-saving technology is extremely difficult, particularly in times of relatively low (compared with the 1970s) energy costs and with a technology that has high capital costs. Gaining industry support before initiating this type of product development is critical to ensure successful technology transfer. However, since industry support and cooperation were not established at the beginning of the project and since this product has shown that it is capable of reducing energy consumption in chlor-alkali applications, an alternative strategy needs to be adopted.

The installation of the technology in a domestic plant would reduce the uncertainty associated with the technology. Financial support to reduce the capital costs to the chlor-alkali facility could be provided jointly by the OIP and PSI. The technology would then be installed in one cell in a chlor-alkali facility, thus reducing the impact of technical difficulties on the overall output of the facility and allowing side-by-side comparison of energy consumption. DOE could reimburse PSI for capital and installation costs based on the actual amount of energy saved over the existing technology.

FUSED SALT CATALYST

The cement and lime industries are both very energy-intensive; energy costs account for almost half of the production costs for cement in some parts of the world. In the process of both lime and cement manufacture, limestone goes through an energy-intensive calcination process. OIP commissioned the Southwest Research Institute (SwRI) to research and develop a catalyst that would facilitate this process. SwRI developed and tested a number of fused salt catalysts and found that a sodium-calcium compound worked the best. Previous catalyst tests had been conducted on stationary samples. SwRI tested the catalyst on stationary samples in their laboratory and in a small rotary kiln supplied by Capitol Cement Company in San Antonio, Texas. The test in the rotary kiln increased the calcination rate by 25% to 35% with a catalyst addition rate of only 5% by weight of limestone. Assuming an acceleration of only 20% in the calcination process with the catalyst, its use would save 110 trillion Btu annually, a savings of $300 million a year.

MARKET-RELATED ISSUES

Early press releases regarding the catalyst came at a time of very high energy prices and prompted hundreds of letters from companies all over the world who were very interested in the catalyst. These industries included limestone and cement manufacturers, pulp and paper mills, and sugar refineries. SwRI invited each company to participate in a field study at each company's expense to test the catalyst. The proposed field tests coincided with the recession of the early 1980s, which caused energy prices to drop drastically. As a result, interest in the catalyst decreased. The recession also decreased profit margins and manpower supplies, making it difficult for companies to adopt the catalyst. Foreign investors bought many of the plants and instituted their own energy saving measures that further reduced the incentive to use the catalyst. Of the hundreds of companies that wrote, only about a dozen volunteered to field test the catalyst. Each was sent a 1-kilogram sample of the catalyst. Of those companies, only three completed the testing, 1 domestic firm and 2 foreign plants. These tests consisted of dry runs in a rotary kiln with varying temperatures and amounts of catalyst. Feedback from these companies was very good, with calcination rates of 30% to 40% being reported.

SwRI has not done any formal market research because of the overwhelming letter response. Although SwRI holds the patent to their salt-fused catalyst, they are not currently marketing it; and no further research is being done. Other salt-based catalysts had been patented previously, but these increased the calcination rate by only 1% to 3%. These catalysts were developed at a time when an acceleration rate of only 5% would have been considered very impressive, but the current low fuel prices have completely extinguished any interest in the catalyst.

Capital costs to develop the salt-fused catalyst have been estimated by SwRI at $0.01 per pound in a new plant and $0.37 per pound in existing facilities. For a plant purchasing the catalyst elsewhere and using it in its calcination process, the payback period is only one production run. Although the catalyst is not difficult or expensive to make, companies that would use the catalyst appear to be reluctant to take on the task of manufacturing it themselves.

One promising application that has not been tested is the use of the catalyst in a fluidized bed reactor. A fluidized bed reactor is similar to a chimney with a heat source at the bottom suspending the chemicals in the air inside the reactor. The catalyst is added. When the reaction is complete, the final product is blown out one end of the chimney, while the heavier catalyst remains in the reactor for the next production run. Fluidized bed reactors have the advantages of being energy efficient; having even heat distribution; and allowing more surface area contact between catalyst and chemical, which speeds the chemical process. Fluidized bed reactors are just becoming popular in the cement and lime industries with lime manufacturers using them in the calcination process. Although it recommended testing in a fluidized bed reactor, DOE has been unable to find one to use.

RECOMMENDATION

Inform companies of the success of the catalyst.

Companies might be more willing to use the catalyst if a licensed manufacturer could supply a ready-made product. Energy prices may have to rise substantially before industries start looking for energy saving devices, but an energy savings of 30% to 40% should be attractive to a plant regardless of current energy prices. The catalyst could be marketed by informing companies (that expressed the initial interest) of the success of the catalyst in the field tests. This might renew their interest and might even induce a company to manufacture the catalyst. Although the future market seems to depend primarily on energy prices, informing the cement and lime industries of the catalyst's success is the next step in commercializing the fused salt catalyst.

INDUSTRIAL HUMIDITY SENSOR

Under contract to the DOE, Honeywell developed a dew point technology to help reduce the amount of energy used in drying processes. The device is fabricated on a silicon integrated circuit chip and measures the dew point temperature in the drying chamber. Honeywell's device proved to be extremely rugged and accurate in contaminant-free environments. However, the introduction of small amounts of organic materials, such as those present in grain dryers, reduces the accuracy of the sensor. The reduced accuracy may be the result of either defective filters or filter seals. Honeywell has not pursued research to rectify this problem and continues to buy sensors from other companies.

Honeywell developed the sensor hoping to enhance the sale of large industrial sensors and control systems by offering an extensive line of sensor options. The humidity sensor is just one of these options. Honeywell sent the sensor to the University of Minnesota for testing. Most of the Honeywell sensors tested survived the rigors of the grain dryers. However, some of the sensors experienced a shift in indicated dew point.

To date, the technology has not been sold, nor has it been used in any Honeywell equipment. The technology has not been licensed; however, a small company, Sentry Technologies, has expressed an interest in the technology. Although no formal agreement has been reached with the company, Honeywell expects to provide technical support to Sentry to assist them in establishing a manufacturing facility.

MARKET-RELATED ISSUES

Honeywell conducted research to identify the potential market for this technology. The operating assumption for this analysis was that the sensor would provide a certain level of accuracy. Unfortunately the sensor does not provide the level of accuracy in grain-drying applications that was assumed for the market analysis. Also, the sensor does not have any inherent advantages over existing sensors in non-agricultural applications. However, the sensor has proved to be extremely rugged, and mass production may make it less expensive than existing sensors. Also, the sensor has lower mass that allows for quicker response time. Because of the expense of commercialization, Honeywell is not interested in developing the sensor for non-agricultural markets.

No continuous sensors that can withstand the contamination of the grain-drying environment are currently available nor are any being developed. The principal alternative to the Honeywell continuous sensor is to interrupt the drying process, remove a grain sample, and measure the humidity. However, this method requires interrupting the drying process for an extended period of time.

Given the fact that drying process applications consume almost 2.0 quads of energy and that 10% of that energy is wasted because inadequate moisture control results in overdrying, a market for a continuous humidity sensor would be available. This market would continue to grow as the relative price of energy increased.

RECOMMENDATIONS

Find a small company, such as Sentry, that would be interested in the device.

Honeywell is not interested in developing the sensor for either agricultural or non-agricultural markets. According to Honeywell's engineering staff, the sensor contamination problem can be corrected either by using a two-stage filtration system or by making the device self-cleaning.

The major problem becomes one of finding a company that would be willing to develop and then manufacture the device. A strategy would be to find a small company that would be interested in manufacturing and marketing the current device for non-agricultural applications and that would be willing to perform the necessary research to reduce or eliminate the contamination problem. If this technical barrier could be overcome, the grain-drying market should be interested in the device.

KILN DUST/FLY ASH AGGREGATE FOR ROAD SYSTEMS

Cement and lime manufacturing produce more than 20 million tons of kiln dust annually, most of which retain many of the characteristics of the cement and lime. OIP sponsored a study to explore using these waste material kiln dusts in a kiln dust/fly ash aggregate for road systems. Currently, road systems are constructed of a variety of materials and compounds including cement, lime, asphalt, crushed rock, cement-fly ash and lime-fly ash aggregates. Different compounds of kiln dusts were developed and tested at Valley Forge Laboratories, Inc., in Devon, Pennsylvania. Used properly, the kiln dust/fly ash aggregate seems to perform as well as the other materials and is cheaper than asphalt and the cement/fly ash and lime/fly ash aggregates.

Fly ash is a waste material produced by coal-fired electric utility plants. If commercial use of fly ash was promoted more by the electric utilities the kiln dust/fly ash might be more accepted in the marketplace. However, the utilities pay a disposal fee to get rid of the fly ash, and they pass this fee on to their customers. Thus, utilities have no incentive to put forth the effort to promote fly ash as a building material.

MARKET-RELATED ISSUES

The main barriers to commercialization appear to the established road material industries (cement, lime, asphalt) and the highway engineers themselves. The cement, lime, and asphalt industries are competitors of the kiln dust/fly ash aggregate and therefore do not encourage its use. According to one contact at N-Viro Energy Systems, Ltd., these companies' influence in the state governments keeps the kiln dust/fly ash aggregate from being written into the state highway specifications; consequently, it is not used. Highway engineers are also hesitant to use a kiln dust aggregate. The kiln dust aggregate is only slightly cheaper than standard compounds, and the price does not offer much inducement for them to switch to something new. Highway engineers do not like using waste materials in road systems and are already nervous about using fly ash in highway system compounds. They are especially hesitant to use fly ash when it is combined with kiln dust, another waste material.

The kiln dust aggregate can also be used to prepare soil for a road system but the same problems remain: The kiln dust aggregate still competes with the established lime, cement, and asphalt companies; there is only a slight economic incentive to switch; and highway engineers are still nervous about using an aggregate of two waste materials.

N-Viro Energy Systems holds the patent to the kiln dust/fly ash compound and has managed to get the aggregate used in roughly "a million tons" worth of road. Over time, specifications have been developed as to how best to apply the kiln dust aggregate. For example, the kiln dust aggregate is more rigid than asphalt, and this must be taken into consideration when the road is being designed. However, the only way specifications for the kiln dust aggregate could be developed was by trial and error. Consequently, some very ugly road has been laid which, fair or not, serves as a monument to the limitations of the kiln dust aggregate. Even though correct specifications have since been developed, the bad roads remain and provide another reason for the highway engineers to refuse to use the kiln dust aggregate.

RECOMMENDATIONS

The opposition is too great and the savings too modest to recommend further research into using the kiln dust/fly ash aggregate in road systems.

The kiln dust/fly ash aggregate does have some advantages over the standard road building materials, but these advantages are not great enough to induce anyone to start using it for road construction or soil preparation. A market study at the beginning of the project might have revealed the opposition to the new aggregate by the road materials industry and the highway engineers.

Although the outlook for using kiln dust in road systems is not promising, N-Viro Energy Systems has developed other industrial uses for kiln dust. Currently they are very successfully marketing use of kiln dust (without fly ash) as a pasteurizing agent that turns sewage into an odorless fertilizer. N-Viro Energy Systems is currently building one new plant a week for this purpose and does not have the time or desire to promote kiln dust for use in road systems.

The kiln dust/fly ash aggregate is also useful in sewage storage, according to N-Viro Energy Systems. When the aggregate is added to sewage, it hardens and creates a solid mass that can be stored without leaching. Research in this area may prove the most fruitful in the successful commercialization of the kiln dust/fly ash aggregate.

An important consideration with the use of kiln dust/fly ash as a roadway material is that fly ash will be classified as a waste by the EPA by the end of 1990. This classification could prohibit its use. Therefore, the environmental regulations need to be addressed before considering the use of fly ash as a surfacing material.

MACHNOZZLE

During 1977, drying accounted for approximately 24% of the energy used in wet textile processing. Developed by a company in the Netherlands, the Machnozzle was tested as a predrying device in an effort to reduce energy requirements in the final drying process. The Machnozzle operates by accelerating steam at sonic velocity through the textile. The speed of the steam literally blows the water out of the textile without a large amount of heat transfer. Once the steam is passed through the fabric, it can be mixed with cold water to create a hot water source for the plant, thereby making the Machnozzle energy efficient.

During the first study, Georgia Institute of Technology (GIT) developed and expanded procedural and engineering modifications to textile-drying processes to reduce energy requirements. Pilot-scale demonstrations investigated the potential of a Machnozzle as a fabric predrying device. The second study focused on the feasibility of the Machnozzle on lightweight fabrics. GIT and J. P. Stevens and Company, Inc., demonstrated the Machnozzle on a commercial scale. A Machnozzle was installed on a continuous finishing range at the J. P. Stevens Delta #1 plant in Clemson, South Carolina.

MARKET-RELATED ISSUES

Although the demonstrations validated the Machnozzle's technical feasibility on lightweight fabrics, no units were sold. At the same time the Machnozzle was being tested, the vacuum slot technology, a competitor, was introduced in the same lightweight fabric market. Since the vacuum slot is a simpler, more understood technology that had been previously used in other applications, it was much more commercially successful than the Machnozzle. The vacuum slot essentially was as effective at predrying fabrics as the Machnozzle.

According to the principal investigator at GIT, no interest has been expressed for further analyzing the technology. The only research idea would be to compare the Machnozzle and the vacuum slot on heavier fabrics. Although this was attempted at one point, the apparatus for the Machnozzle was not properly set and the fabric ripped. According to the principal investigator, a precise study would require about $150,000 of additional funding.

No market assessment was conducted; however, an economic analysis showed the Machnozzle to be an attractive investment. Payback periods could be as short as 3.5 months. The Netherlands company still owns the patent to the technology.

RECOMMENDATIONS

Identify a new market or alter the technology.

A thorough market assessment, especially analyzing the competition, could have prevented the market difficulties encountered by this technology. Since the market's need is being met by the vacuum slot technology, several efforts are possible. Either a new market for the existing Machnozzle should be identified, such as in the pulp and paper industry, or the technology should be altered to meet the needs of a new market.

MEMBRANE FOR SOLVENT RECOVERY

Membrane Technology and Research, Inc. (MTR) has developed a membrane process for separating organic vapors from air. The membranes are more permeable to organic solvents than to air. A vacuum pump on the permeate side of the membrane draws organic vapors through the membrane, producing two streams: a solvent-depleted air stream and a concentrated solvent-rich permeate stream. Solvent is recovered from the latter stream by cooling and condensation.

The modules have been evaluated in the laboratory and in field trials. Based on these results, a number of process design and economic calculations have been performed. The cost of the process primarily depends on the type of solvent being removed, the solvent's reuse value, the availability of cooling water, and the concentration of the feed air. A particularly important parameter is the required solvent removal fraction. Most industrial vapor separation systems will remove between 50% and 90% of the solvent. Higher degrees of solvent removal can be achieved, but this degrades the permeate concentration and increases the costs of the system. Operating costs can be largely offset by the value of the recovered solvent if feed air solvent concentrations are greater than 0.5%.

MARKET-RELATED ISSUES

MTR decided to commercialize the technology about two years ago; marketing activities started about 18 months ago. Ten units have been built. Nine systems treat 40-50 scfm of solvent-containing air. One unit treats 100 scfm of solvent-containing air. Six of the units are pilot systems used to evaluate the system for both in-house and outside clients. Three small units have been sold for commercial use. The names of the companies are proprietary to MTR.

Although MTR does not have a sales force, they are in the process of developing markets. Specifically, they are concentrating on determining the best markets for the technology and how to market to those customers. The general markets MTR has targeted are primarily those markets that use CFCs and other volatile organic solvents. Fluorinated hydrocarbons are very expensive to use and result in many environmental problems. In fact, industries producing solvent-containing air streams are under increasing pressure from environmental regulatory agencies to curb emissions of many widely used solvents. Some form of treatment is required to meet air pollution standards; and these treatments are usually expensive.

The specific niches MTR has identified are CFC and HCFC primary solvent users. The principal CFC users with whom they are establishing relations are refrigeration companies who need to recover coolant vapor, hospitals who use CFC-12 mixtures to sterilize equipment, companies involved in degreasing activities, and solvent manufacturers. According to the marketing director, discussions with people in these industries, as well as early sales, indicate that there is substantial interest in membrane technology.

Currently MTR has the "lock" on the market since they are the only company supplying membranes of this type. However, MTR lacks sufficient capital and experience to fully exploit all the market opportunities for their product. The technology fills a gap in the market; however, since the technology is new, people are slow to adopt it. Users who have adopted it have generally done so because no other alternatives were available.

The primary competing technologies are carbon adsorption and incineration. At high concentrations, carbon adsorption is expensive, and air streams must be diluted. Incineration is useful only for removal of solvents, not for recovery.

The payback on the membrane technology is a few months on "good" streams; i.e., high concentrations of high-value effluent. Since CFC compounds are assessed with a scaled tax, many companies can have a short payback period. Environmentally, the technology is justified.

Other attractive features of the technology are its compact size, reliability, "good economics," performance (it creates a complete separation with no by-products or solid carbon waste), and straightforwardness.

According to MTR, funding to install a large-scale (250-500 scfm) membrane unit would be the most helpful activity to get the technology accepted in the marketplace. MTR would like to assure the market that the technology is successful. One contact feels that the large-scale membrane unit needs to be subsidized by some organization such as DOE since the users are unwilling to assume the entire risk. MTR estimated that about $2-300,000 or more would be required to design and install a 250-scfm unit.

According to the marketing director, MTR is seeking marketing partners who could license the technology for their specific area of interest.

RECOMMENDATIONS

An in-depth market analysis should be conducted.

Since little formal marketing research has been done, MTR might profit from an in-depth market analysis. Although a few people in each industry have expressed interest in the technology, they do not necessarily speak for their entire industry. Although the principal investigator of the technology feels that a large-scale membrane would be beneficial, a more cost-effective approach would be to focus on getting a greater number of smaller membranes in the market. Several small units operating in various applications could demonstrate the feasibility and attractiveness of the technology. In this way, the market would gain confidence in the technology. Once this confidence is attained, MTR could eventually begin marketing larger units.

If, however, MTR feels the large membrane is the only worthwhile venture, they should concentrate on one market in which they think they will have the most success. By concentrating on a smaller segment of the market, MTR can achieve better success through more efficient use of their resources.

In the long run, MTR's broad marketing ideas will be beneficial; however, their short-term marketing efforts need to be more focused and perhaps more formal.

SPECTRAL FLAME ANALYZER

The Spectral Flame Analyzer (SFA) identifies different gases present in a boiler that may be indicative of incomplete or inefficient combustion. Each gas or combustion "species" emits a unique signal that shows up under spectral analysis. This signal enables the burner operator to determine what gases are present in the burner and to evaluate combustion. Depending on the gases present and the spectral analysis, the boiler operator can adjust boiler parameters to maximize fuel and burner efficiency. The SFA would enable each burner to operate at its most efficient air/fuel ratio, resulting in optimum fuel combustion and reduced pollutants. No market studies have been done, but, according to one contact, the SFA would be applicable in industrial and utility boilers and multi-burner furnaces.

Work on the SFA was contracted through the DOE-Idaho Operations Office (Idaho National Engineering Laboratory) to Thermo Electron. The SFA has been tested in the Combustion Research Facility at MIT and field tested at Polaroid Corporation's fuel-oil-fired boiler plant. The Electric Power Research Institution sponsored a test of the SFA at the Potomac Electric Powe Company in a 400-megawatt coal-fired boiler. The results of this test showed that at this stage of development the SFA could highlight differences between burners but could not tell what caused the differences. The burners had to be removed before the problem could be effectively diagnosed.

MARKET-RELATED ISSUES

In its present state of development, the SFA has limited use as a diagnostic tool to determine problems with atomization and worn burners. Merely identifying that a problem exists rather than pinpointing the problem is not sufficient, and the SFA is not marketable in its present state. The SFA could indicate specific problems as well as reduce burner replacements if an algorithm were developed. For example, a plugged oil gun may be resulting in poor oil distribution. At present, there is no way to determine which burner is causing the problem, and all the oil guns would probably be replaced. If the SFA could indicate which burner is causing the problem, only the defective burner would be replaced.

Successful commercialization of the SFA will require the development of an algorithm that can correctly link changes in boiler parameters to changes in the SFA output signals. Boiler parameters include firing rate, swirl, and the air/fuel ratio. Changes in a single boiler parameter can be accurately predicted in the spectral signal, but changes in more than one variable at a time do not result in a consistent spectral signal. Development of the algorithm was to be Phase III of a three-phase project, and Thermo Electron requested an additional $1 million to develop the algorithm. The DOE declined funding and expressed doubts that the algorithm could be developed even with the additional money. Currently, no effort is being made to develop the algorithm or to research the SFA further.

If the algorithm were developed, the SFA probably could be successfully commercialized. DOE estimated the simple payback time to be 1 to 3 years, but the payback model used by Energetics to estimate the SFA payback was never run successfully because a lack of cost data from private sector development. However, Thermo Electron estimates the payback to be very short: between one and twelve months with fuel savings as high as 2% of total energy. On larger, more extensively used boilers, the payback period is shorter, sometimes as short as one month. The outlay by the consumer may be reduced if a scanning device were developed with the SFA rather than one unit per burner. This would allow the SFA to scan the boiler and monitor multiple burners. This idea is more of a marketing scheme and has not been pursued because the SFA is not yet a developed and successful finished product.

RECOMMENDATION

The SFA should remain archived.

A large amount of research needs to be done to develop a fundamental understanding of burner emissions. Until emissions are understood enough to develop an algorithm that links changes in parameters to changes in spectral signals, the SFA is not marketable. The amount of research required to find the algorithm may be so great that it might not be worthwhile to pursue developing the SFA any further. However, if the algorithm were to be discovered in some other research project or if fuel prices were to rise enough to warrant further research in burner efficiency, the SFA technology could eventually find a place in the market. The SFA should remain archived until burner emissions are well enough understood to allow the economic development of the missing algorithm.

APPENDIX A

OIP QUESTIONNAIRE

APPENDIX A

OIP QUESTIONNAIRE

I am trying to determine what can be done to help the commercialization of some OIP-sponsored technologies. One of the technologies that I am reviewing is ____________. Specifically, I am interested in establishing the current stage of development, the commercial status of the technology, any barriers that prevent commercial use and any insights that you have as to how to improve the market acceptance.

Technology Status

1. Is the technology technically successful?

If unsuccessful:

2. Is there anything that can be done technically to make the technology more viable in the marketplace? If so, what?

3. Is your company actively pursuing this research?

4. Do you anticipate barriers to acceptance of this technology in the marketplace? If so what are they?

If successful:

5a. Have you applied for a patent?

5b. Have you licensed the technology? If yes, to whom?

5. Has your product been sold in the marketplace?

6. If so, to whom? Names, addresses and telephone numbers.

7. What feedback have you received from any of your customers regarding the performance of the technology?

8. If you have not sold any units, what barriers do you feel prevented commercial acceptance?

Market Status

9. What have you done to determine the market need for this technology? Have you conducted focus groups, talked to people at conferences, formal market analyses, etc.?

10. If you have, what were the results of this analysis? Did you identify specific market niches for the technology?

11. How have the results of this analysis redirected or revised your research activities?

12. Are your sales as large as you predicted?

13. What are the competing technologies that are either currently available or that ar being developed?

14. What is the relative advantage of your technology over competing technologies?

15. Is your technology price competitive with existing technologies?

16. If not, what changes would be necessary to make it competitive?

17. Is your company actively pursuing this research?

18. Do you use your own sales force? If not, whom do you use?

19. What type of advertising or promotion have you done?

20. Whom else should we contact for information on this technology?

APPENDIX B

CONTACTS AND SOURCES

APPENDIX B

CONTACTS AND SOURCES

Extraction of Organics from Water

Kingsley, G. S., M. E. Chung, and J. M. Moses. 1986. "Cosolvent-Enhanced Critical-Fluid Extraction of Organics from Water," final report for the period August 14, 1984-August 14, 1985. Prepared for the U. S. Department of Energy, by Critical Fluid Systems, Inc., Cambridge, Massachusetts, under contract no. FC01-84CE40673.

Abboud, O. K. et al. 1984. "Critical-Fluid Extraction of Organics from Water, Volume II: Experimental," final report for the period October 1, 1979-November 30, 1983. Prepared for the U. S. Department of Energy, by Arthur D. Little, Inc., Cambridge, MA, under contract no. AC01-79CS40258.

Moses, J. M. and R. P. de Filippi. 1984. "Critical-Fluid Extraction of Organics from Water, Volume I: Engineering Analysis," final report for the period October 1, 1979-November 30, 1983. Prepared for the U. S. Department of Energy, by Arthur D. Little, Inc., Cambridge, Massachusetts, under contract no. AC01-79CS40258.

Abboud, O. K. et al. 1984. "Critical-Fluid Extraction of Organics from Water," final report for the period October 1, 1979-November 30, 1983. Prepared for the U. S. Department of Energy, by Arthur D. Little, Inc., Cambridge, Massachusetts, under contract no. AC01-79CS40258.

Contacts:

Environmental Protection Agency
SITE Program (former employee)
Washington, DC

Clean Harbors Company
Boston, MA

Critical Fluid Systems
Waltham, MA

Fuel Cell Membrane

Taylor, E. J. et al. 1988. "Transport and Conductivity Properties of an Advanced Cation Exchange Membrane in Concentrated Sodium Hydroxide." Submitted to *Journal of Membrane Science*, August 1988. Prepared by PSI Technology Company, Andover, Massachusetts.

Anderson, E., E. J. Taylor, N.R.K. Vilambi, and A. Gelb. 1989. "Application of Fuel Cell Technology to Energy Savings in the Chlor-Alkali Industry." PSI Technology Company, Andover, Massachusetts, under contract no. DE-AC-0286ER80366.

Taylor, E. J. 1989. "The Chlor-Alkali Industry in the U. S. and Japan, A Case Study of Technological Innovation 1970 - 1980."

Anderson, E. et al. September 26, 1989. Presentation by PSI Technology Company, Andover, Massachusetts, to Japan Soda Industry Association, Tokyo, Japan.

Contacts:

Physical Sciences, Inc.
Andover, MA

Industrial Humidity Sensor

Honeywell Solid State Electronics Division. 1988. "Improved Industrial Humidity Sensor," final technical report. Prepared for the U. S. Department of Energy, Idaho Operations Office, Idaho Falls, Idaho, sponsored by the Office of the Assistant Secretary for Conservation and Renewable Energy, Office of Industrial Programs, under contract no. DE-FC07-84ID12558.

Contacts:

Honeywell
Plymouth, MN

Kiln Dust/Fly Ash Systems for Highway Bases and Subbases

Collins, R. J. and J. J. Emery. 1983. "Kiln Dust-Fly Ash Systems for Highway Bases and Subbases," final report, February 1981-October 1982. Prepared for the U. S. Department of Energy and the U. S. Department of Transportation, Federal Highway Administration, by Valley Forge Laboratories, Inc, under contract no. DTFH61-81-C-00037.

Contacts:

Federal Highway Administration
McLean, VA

N-Viro Energy Systems
Toledo, OH

Machnozzle

Brookstein, D. S., W. W. Carr, and W. D. Holcombe. 1980. "Development and Demonstration of Energy-Conserving Drying Modifications to Textile Processes." Prepared for the U. S. Department of Energy, Assistant Secretary for Conservation and Solar Energy, Office of Industrial Programs, by Georgia Institute of Technology, School of Textile Engineering, Atlanta, Georgia.

Carr, W. W. et al. 1981. "In-Plant Demonstration of a Mac' .ozzle as a Fabric Predrying Device." Prepared for the U. S. Department of Energy, Assistant Secretary for Conservation and Solar Energy, Office of Industrial Programs, by Georgia Institute of Technology, Engineering Experiment Station and School of Textile Engineering, Atlanta, Georgia.

Contacts:

Georgia Institute of Technology
Atlanta, GA

J.P. Stevens (former employee)
Clemson, SC

Membrane for Solvent Recovery

Baker, R. W. et al. 1987. "Membrane Research in Energy and Solvent Recovery from Industrial Effluent Streams," final report for the period of performance November 1, 1982-November 31, 1987. Prepared for the U.S. Department of Energy, Office of Industrial Programs, by Membrane Technology and Research, Inc., Menlo Park, California.

Contacts:

Membrane Technology and Research, Inc.
Menlo Park, CA

Fused Salt Catalyst

Mallow, W. A., J. J. Dziuk, and K. E. Daugherty. 1984. "Development of Low Energy Methods for Production of Lime," draft final report. Prepared for the U. S. Department of Energy, Division of Industrial Energy Conservation, by Southwest Research Institute, San Antonio, Texas, under contract no. DE-AC03-82CE40560, SwRI project no. 06-7318.

Contacts:

Southwest Research Institute
San Antonio, TX

Spectral Flame Analyzer

Metcalfe, C. I. and W. E. Cole. 1987. "Development of Spectral Flame Analyzer for Individual Burner Control in Boilers," final report. Prepared for the U.S. Department of Energy; Idaho Operations Office, Idaho Falls, ID. Sponsored by the Office of the Assistant Secretary for Conservation and Renewable Energy, Office of Industrial Programs. Prepared by Tecogen Inc., a subsidiary of Thermo Electron Corp., Waltham, Massachusetts, under contract no. DE-AC07-83ID12463.

Contacts:

Idaho National Engineering Laboratory
Idaho Falls, ID

Thermo Electron Corporation
Waltham, MA

Energetics
Columbia, MD

END

DATE FILMED

11 / 29 / 90