RECENT DEATHS

William S. Barnhart, 58; senior polymer scientist, Pennwalt Corporation; 6 May.

E. Jefferson Browder, 81; professor emeritus of neurosurgery, Downstate Medical Center, State University of New York; 1 May.

Harold Cummins, 82; professor emeritus of anatomy, School of Medicine, Tulane University; 12 May.

Kenneth C. Francis, 53; clinical professor of orthopedic surgery, New York University Medical Center; 17 May.

Wilbur A. Lazier, 76; first director, Southern Research Institute; 14 May.

Thomas M. Reed, III, 54; professor of chemical engineering, University of Florida; 5 March.

John S. Rendleman, 48; president, Southern Illinois University, Edwardsville; 4 March.

Arthur H. Smith, 83; professor emeritus of physiological chemistry, Wayne State University; 19 March.

Guy-Harold Smith, 69; professor emeritus of geography, Ohio State University; 7 April.

Lyle M. Stanford, 65; professor of biology, College of Idaho; 20 April.

Emily L. Stogdill, 82; professor emeritus of psychology, Ohio State University; 14 March.

William S. Taylor, 82; professor emeritus of psychology, Smith College; 12 April.

Ivo T. Thomas, 64; professor of mathematical logic, University of Notre Dame; 2 February.

Kenneth F. Tritabaugh, 52; engineer, Applied Physics Laboratory, Johns Hopkins University; 8 February.

Edward L. Ullman, 63; professor of geography, University of Washington; 24 April.

Miriam E. Urdang, 58; associate professor of education, Queens College, City University of New York; 1 March.

RESEARCH NEWS

Rerefined Oil: An Option that Saves Oil, Minimizes Pollution

Half a billion gallons of oil is small change, less than half a percent of the annual oil consumption of the United States. But considered as a pollutant, half a billion gallons of oil is a staggering amount—more than the combined annual release of DDT's, polychlorinated biphenyls, aldrins, dieldrins, mirexes, and all the other highly publicized chemicals that are commonly perceived to be detrimental to the environment. Yet half a billion gallons is roughly how much used lubricating oil is released into the environment each year. It is applied to dirt roads, dumped into landfills, poured into sewers, flushed down toilets, splashed into waterways, or simply spilled into countless thousands of backyards across the country.

This oil spoils the taste of water, endangers the health of many kinds of organisms, and releases substantial quantities of poisonous metals into the environment. Yet this kind of pollution can be avoided relatively easily. If this oil were systematically collected, it could be rerefined into new lubricating oil or, less desirably, burned as a fuel under carefully controlled conditions. In the past, the government has been indifferent to the prospects for collection and reuse of this oil and, in some cases, has been actively obstructive. Economics have also been a major obstacle in the path of the small entrepreneurs who have attempted to make some use of this potential resource.

But the situation is changing. Several groups, spurred in large part by the energy crisis and the increased cost of virgin oil, have developed new rerefining processes that eliminate many of the environmental pitfalls characteristic of older technology. Federal and local governments have become noticeably more interested in promoting the collection of used oils. And, perhaps most important, the federal government has begun to consider ways of removing some of the hindrances to reuse of lubricating oils. The Federal Energy Agency (FEA) estimates that reuse of the wasted oil would reduce oil imports by about 70,000 barrels per day, or about 7 percent of the Administration's energy conservation goals. More important, according to FEA's Robert Marlay, the achievement would be a highly visible symbol of the nation's conservation effort.

Last year, more than 2.4 billion gallons of lubricating oil were sold in the United States, nearly 2 percent of U.S. consumption of petroleum. About half of this oil was consumed in use, discarded with filter cartridges, or lost through leakage. About 60 percent of the remaining 1.2 billion gallons was recovered from automobile crankcases. The remainder came from industrial and aviation applications.

According to the Environmental Protection Agency (EPA), nearly 600 million gallons of this oil was burned as fuel. Another 200 million gallons was used as road oil or incorporated into asphalt, and 110 million gallons was rerefined into lubricating oil. The remaining 290 million gallons simply disappeared. Combined with the oil used on roads, that makes a total of nearly 500 million gallons released into the environment.

The waste oil itself is still good, but contamination with a variety of materials makes its use difficult unless it is cleaned up first. The most important contaminants are the additives that are used to improve the lubricating properties of the oil and oxidation products of the additives and the oil. Also present are volatile components from gasoline and diesel fuel, carbon, sediment, water, metallic particles from engine wear, and metals from gasoline. The used oil cannot simply be mixed with crude at a refinery and cleaned up there because the metals would poison catalysts and many of the contaminants foul distillation columns. Burning the oil without treatment simply releases most of the contaminants into the air. The best solution is to remove the contaminants before the oil is used, and the need to do so has created a new industry.

At one time early in this century, several hundred companies throughout the country were engaged in rerefining used oils. But that industry has fallen on hard times. Whereas there were as many as 150 rerefiners only 10 years ago, today there are about 30. A number of factors have contributed to the decline. One of them is economics. Higher labor and transportation costs have made it almost prohibitively expensive in many areas to collect used oil. The higher cost of virgin oil has also increased the amount of used oil that is burned for fuel, thereby reduc-

ing the amount available for rerefining. Many rerefiners are now operating at about 50 percent of capacity because of lack of feedstock.

Changing patterns of distribution are also hurting the industry. A few years ago, nearly all automotive lubricating oil was sold by service stations, which then collected the used oil during the oil change. Now, however, some 48 percent of automotive oil is retailed by discount stores and other outlets. Since there are few places where people who change their own oil can bring it for recycling, this oil is lost from the system—generally to the detriment of the environment.

The government has also erected roadblocks that have harmed the industry. In all fairness, though, it must be recognized that some of these barriers were necessary to prevent unscrupulous activities by a few oil merchants. In the 1930's and 1940's, some merchants would simply allow the sediment to settle out of used oil, repackage the oil, and sell it as new. Others treated the oil, but still produced an inferior lubricant.

Because there were, and still are, no simple tests to judge the quality of lubricating oils, the Federal Trade Commission (FTC) ruled that all rerefined oil must carry the designation "made from previously used oils." Government procurement specifications were also changed so that rerefined oil could not be purchased for use by government agencies or the military. Rerefiners argue that these actions smeared the good along with the bad and have grossly reduced their sales, but their complaints, until recently, have fallen on deaf ears.

A complicated federal tax structure has also created problems for rerefiners. Between 1942 and 1965, an excise tax of 6 cents per gallon was levied on virgin oils but not on rerefined oils, producing a tax advantage for the rerefiners. But in 1965, Congress removed the excise tax on all lubricating oils except those used in automobiles. Manufacturers still paid the tax and passed it along to users, but off-highway users such as farmers, construction contractors, and railroads—each of which was a major market for rerefined oil—could apply for and receive a refund of the tax. Furthermore, the Internal Revenue Service ruled that the refund for virgin oil could not be given if the oil was mixed with rerefined oil. Since many rerefiners blend their product with virgin oil, the net effect was that rerefiners went from a tax advantage to a tax disadvantage.

The industry has also been hampered by old technology. Most rerefiners are quite small companies with limited capital. They have thus generally not been able to invest in research and development for new processes or the purchase of technology developed by other companies. Instead, they have had to make do with inefficient technology that is also, unfortunately, detrimental to the environment.

The most important step in any rerefining process is removal of as many of the contaminants as possible. In the traditional process, this is accomplished by treating the used oil with concentrated sulfuric acid, which precipitates most of the additives and sediment and a large portion of the metals. The oil is then typically vacuum-distilled and finished by decolorizing with clay. The acid sludge produced in the first step is a highly toxic material containing lead and barium, and is difficult to dispose of properly. Often, it is simply dumped into a landfill, where the acid and metals may leach into groundwater. The clay used to finish the oil (which still contains residual oil) must also be dumped into a landfill. This dumping is not only environmentally undesirable, but is also quite expensive, and is thus responsible for a substantial portion of the cost of rerefining.

Several New Processes

The technological problems may be the easiest to solve. Several independent entrepreneurs, large companies, and the government have each developed new—and generally similar—processes that alleviate many of the problems associated with the old technology and that produce lubricating oil of high quality. A recent EPA report, in fact, contends that adequate technology for rerefining used oils is available now and that the principal problem is implementing it.

A selection of the technology:

▶ S. R. Bethea and his associates at the Baytown Petroleum Research Laboratory, a division of the Exxon Research & Engineering Company in Baytown, Texas, have developed a process that consists essentially of vacuum distillation followed by Hydrofining, a hydrogenation process for finishing the oil. Exxon has concluded, however, that it would be too difficult to try to license the process to the many small rerefiners and has placed the technology in the public domain. The National Oil Refining Company of Bayonne, New Jersey, is now constructing a plant based primarily on this technology.

▶ Morton Z. Fainman of MZF Associates in Bel Air, California, has developed a similar process that incorporates a preliminary step in which contaminants are extracted with aqueous isopropyl alcohol. Evaporation of the alcohol-water mixture (which is recovered for recycling) leaves a small amount of sludge containing as much as 30 percent lead. It may be possible to recover metals from the sludge. After extraction, the oil is vacuum-distilled and hydrogenated. MZF is now constructing a 500,000-gallon-per-month plant in Signal Hill, California, to use the process.

▶ Marvin L. Whisman and his associates at the Bartlesville Energy Research Center, an Energy Research and Development Administration (ERDA) laboratory in Bartlesville, Oklahoma, have developed a similar process. In their process, though, a mixture of organic solvents is used for the extraction, and either clay or hydrogenation can be used for finishing the oil. They have tested the process in leased pilot plants at three locations throughout the country.

▶ Institut Français du Pétrole (IFP) has a more complicated process that it is trying to market in the United States. The process includes a short preliminary distillation, extraction with propane, treatment with acid, vacuum distillation, and finishing with clay. One plant using the IFP process is operating near Milan, Italy, and a second is under construction in northern Europe.

▶ Edward T. Cutler and the late Louis E. Cutler of Pilot Research & Development Company, Merion Station, Pennsylvania, have developed a process that consists of propane extraction, vacuum distillation, and Hydrofining. The PVH process, as it is named, is thought by many to be highly innovative, but has so far been tested only on a laboratory scale. Pilot is currently seeking a company interested in constructing a plant to test the process.

An objective comparison of the processes is difficult to obtain, but a few conclusions can be drawn. One is that some sort of extraction or sedimentation step is going to be necessary for a commercially successful process. The additives in used oil foul distillation columns badly, Whisman says, and continuous operation of a plant without removal of the additives from the feedstock will be difficult. The primary difference among the competing processes is how the additives and other contaminants are removed.

The alcohol and organic solvents used for extraction of contaminants in some of the processes have an advantage over propane in that the processes using them can be operated at room temperature and pressure. But the solvents are expensive and costs can be kept down only if there is a high degree of recovery when they

are recycled. Furthermore, more energy is required to separate the solvent from the extracted sludge than is required with propane. While propane is much cheaper than the organic solvents and requires less energy for recycling, it must be used in high-pressure equipment that requires technical sophistication often lacking in small rerefining companies. The IFP process, furthermore, requires substantially more propane than the PVH process.

Removal of contaminants in the preliminary steps also reduces the cost of the finishing step. The more contaminants that are present during finishing, the greater the amount of hydrogen or clay that will be required. This might not be a problem if the rerefinery is located next to a conventional refinery where cheap hydrogen is available, but it will be quite important in an isolated location where hydrogen must be purchased or produced at the site.

There are, of course, differences of opinion about the relative efficiencies and costs of the various processes. But, in general, the efficiencies range from 60 to 75 percent (the rest of the feedstock is converted into sludge or recovered as a heavy oil that is either disposed of, burned for fuel, or used as an ingredient in asphalt) and the operating costs range from 12 to 18 cents per gallon, exclusive of the cost, if any, of the used oil. Capital costs range from $1.5 million to $2 million for a plant based on acid-clay technology to about $4.3 million for a 500-barrel-per-day plant based on the PVH process. In general, the plants with the highest capital costs have the lowest operating costs and thus may be the cheapest in the long run. But most small rerefiners do not have the capital to erect even an acid-clay plant, so people like Cutler are turning to investors outside the industry to try to get fresh capital.

Some of that capital might become available if some of the other problems of rerefiners could be resolved, and it appears that progress is being made in that area. A prime example is the Energy Policy and Conservation Act signed by President Ford last December. That act requires the National Bureau of Standards (NBS) both to demonstrate the equivalency of rerefined and virgin lubricating oils and to develop simpler ways to measure the quality of lubricating oils. Quality is now determined in what is known as automotive engine sequence tests. In them, the oil to be tested serves as a lubricating agent in an engine that is run through a specific sequence of operations for an extended period. The engine is then disassembled and checked for wear, corrosion, and so forth. These tests can cost as much as $20,000 for one oil sample, so rerefiners have not been able to afford to demonstrate the quality of their products.

The petroleum industry has been working for more than 30 years to develop a cheaper way to measure the quality of lubricating oil—so far without success. Many people think NBS will have little better success, particularly since, as John Hoffman of NBS concedes, the bureau does not have any personnel experienced in working with oil. The task of NBS is further complicated by the fact that Congress has not appropriated any funds to carry out the research; hence, funds will have to be siphoned from other NBS projects. So far, the agency has been merely acquiring information and trying to formulate a plan of action, and it may be some time before actual research begins.

NBS will apparently get some assistance from other federal agencies in demonstrating the equivalency of virgin and rerefined lubricating oils. At least two other agencies have already begun their own projects to do this. ERDA, in association with the Association of Petroleum Rerefiners, selected a representative sample of commercial rerefined oil and submitted it to engine sequence tests. The oil, produced by Motor Oils Refining Company of Chicago, passed the tests, suggesting that the manufacturers' claims of equivalency are valid. ERDA is also sponsoring a program at Iowa State University in which half of a fleet of cars and trucks will use virgin lubricating oil and half will use rerefined oil. Oil samples from both groups will be tested periodically by spectroscopy to assess engine wear and, at the end of the project, the engines will be disassembled. The test should provide a good demonstration of the quality of rerefined oil in actual use.

Before the passage of the Energy Policy and Conservation Act, Lawrence McEwen of EPA had begun a program to collect samples of rerefined oil from each of the producers in the country—presumably in anticipation that Congress would award to EPA the program that went to NBS. EPA, in cooperation with the Department of Defense, will continue the program and submit each of these samples to engine sequence tests. NBS, according to Hoffman, is watching all of these studies closely and will include as many of the results as possible into its own program. FTC is also monitoring the tests, and results obtained in them might be the basis for changes in the labeling of rerefined oils. A successful conclusion to the tests might also lead to a change in military procurement specifications.

Congress is also moving to change the tax structure for rerefined oils. The House in June passed a bill (H.R. 6860) that would permit a refund of the excise tax for off-road use of blends of virgin and rerefined oils. The Senate has passed a similar measure in the Tax Reform Act of 1976, and the two different measures must now be reconciled in a conference committee.

Perhaps the most enthusiastic federal agency is FEA, which is taking several actions to promote reuse of oil. One of its major actions was the commissioning of a model Used Oil Recycling Act, drafted by William A. Irwin of the Environmental Law Institute in Washington, D.C. The model act is designed to help states and communities deal with used oil. Its purpose is to capture as much used oil as possible before it can be released into the environment and channel it into waste recovery purposes.

One of the principal provisions of the model act is to require discount stores and similar outlets that sell substantial quantities of lubricating oil to advertise the location and hours of operation of recycling centers; the stores may be required to participate in the establishment of such centers. Another provision would require licensing of used oil collectors and rerefiners and would prohibit transfer of used oil to unlicensed companies or individuals. Marlay says the agency will make every effort to bring the model act to the attention of state governors and legislators and to encourage them to pass laws modeled after it.

FEA is also preparing a "Waste Oil Recycling Kit," to be available this fall, that will show citizens groups and community organizations how to establish voluntary programs at the local level. The kit is modeled on programs that have already proved successful in California and Minnesota. States and cities, such as Illinois, Vermont, and San Diego, are also organizing programs to promote recycling of used oil.

These efforts may begin to pay off soon. The market research company Frost & Sullivan Inc. of New York City predicts that the rerefining industry will grow at an annual rate of 23 percent between now and 1985. By that year, Frost & Sullivan says, some 125 companies will rerefine about 840 million gallons of oil each year with a value of $1 billion. And if this should come to pass, there should be a lot less oil going into the environment.

—THOMAS H. MAUGH II