An Investigation Into the Recovery and Reclamation of Used Industrial Lubricating Oils

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Abstract

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AN INVESTIGATION INTO THE RECOVERY AND RECLAMATION OF USED INDUSTRIAL LUBRICATING OILS

A Research Paper for Presentation
to the Graduate Faculty
of the
Department of Industrial Technology
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In Partial Fulfillment of the Requirements for
the Non-Thesis Master of Arts Degree

by
Fredric G. Becker
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Problem Background

Where will industrial petroleum base lubricating oils come from in the future? There is a finite supply of new petroleum available for use in the world. After oil is used, it is often discarded as waste that has a serious environmental impact (Safety-Kleen, 1991). Additionally, the disposal of used oil by burning or other irrevocable means is a resource lost forever.

Some (e.g., Safety-Kleen, 1991) take issue with the use of the term "waste oil" to describe used oil. They contend oil is a resource that does not wear out, it only becomes contaminated. Brinkman (1985) and Korane (1986) state that this contamination can be removed and the oil renewed again through proper treatment.

Kimball (1975, p. 16) and Henke (1983, p. 310) point out the development of numerous physical and chemical processes for recovery of used industrial and automotive lubricants. They also address the fact that processes vary in their treatment of the used oil. Some provide only an upgrade of the oil while other more complicated processes return the oil to a condition near that of an original base oil.

Statement of the Problem

The problem of this study was to investigate methods of recovery and reconditioning for used lubricating oil products generated in an industrial manufacturing facility.

Statement of Purpose

The purpose of this study was to investigate available methods for recovery and reconditioning petroleum-based lubricating oils used in the manufacturing industry. These include hydraulic, spindle, and general purpose lubricating oils from equipment in a large industrial manufacturing facility.

Statement of Need

The need for the study was based on the following factors:

1. The need for technology to aid in recovering finite energy resources as provided for in the Resource Conservation and Recovery Act of 1976 (Cheremisinoff, 1979).

2. A Federal Energy Administration estimate indicates reuse of waste oil could reduce oil imports by 70,000 barrels per day, roughly 7% of the governments energy conservation goal in the 1970s (Becker, 197-).

Statement of the Research Question

The research questions to be answered by this investigation were:

What types of processes are feasible for recovery and reconditioning of oily waste generated by a large industrial manufacturing organization?

How do these alternatives compare with the current methods of disposal?

Assumptions

The following assumptions were made in the pursuit of this investigation:

1. The used oil generated at the industrial facility in this investigation consists of a cross-section of the petroleum base

lubricating products that are purchased for internal use.

2. Oil recovered by the processes will be used for lubricating purposes similar to their original application.

3. Federal and State regulations would not drastically change in the near term, specifically the current definitions of hazardous waste and toxic waste.

Delimitations

This study was conducted in view of the following delimitations:

1. The investigation was limited to petroleum base lubricating oils.

2. The type of lubricating oils evaluated was limited to those contributing to the bulk of the waste oil volume.

3. The study was limited in scope to materials that are currently classified as non-hazardous materials per Federal regulation guidelines.

Definition of Terms

The following terms were defined to clarify their use in the context of the study.

Additive: Chemical substance added to a petroleum product to impart or improve certain properties (Schneider, 1989).

Adsorption: Adhesion of molecules of gases, liquids or dissolved substances to a solid surface, resulting in relatively high concentration of molecules at the place of contact (Schneider, 1989).

Basestock: Refining industry term used to describe a pure, single viscosity oil product from refining process.

Commingle: Mix together (McKechnie, J.L., 1979) Applied here to mean a mixture of various types of fluids and their respective contaminants.

Contaminant: Any material or substance which is unwanted or adversely affects the fluid power system or components, or both (Schneider, 1989).

Electrostatic Fluid Cleaning: Process using electrically charged collector plates to attract particulate matter of opposite electrical charge.

Feedstock: Re-refining industry term used to describe the flow of fluid into a process.

Statement of Procedure

The procedure for this investigation was to research literature resources to determine feasibility of applying recovery and reconditioning processing techniques at a large industrial manufacturing facility. The investigation used the descriptive research method. Selection of the research method was based on time, regulatory limits, and capitol restraints.

CHAPTER 2

REVIEW OF LITERATURE

Oil Recycling History

Interest in the recovery of petroleum base lubricants appears to be related to the availability of oil and its products. Brinkman (1985, p. 48), formerly with the National Institute for Petroleum and Energy Research (NIPER), notes that recycling became popular during World War I and again in World War II when oil products were in demand. He goes on to say that the recycling industry continued to grow until 1960, when 150 companies produced over 300 million gallons of lubricants. However, by the mid 1960s the used oil recycling industry had started to decline.

Brinkman (1985, p. 48) attributes the decline to several key items. First, most small recyclers could not keep pace with the technological advancements required to recycle new types of lubricants. Second, the cost to comply with more stringent environmental regulations took their toll on small companies with limited capital.

Another economic blow was dealt to re-refiners in the mid-1960s according to Brinkman (1985, p. 48). Branches of the United States military quit purchasing recycled lubricants because of problems with product quality consistency. State, municipal and industrial users soon followed the example set by the military.

Becker (197-), then with The National Bureau of Standards (NBS), identified several obstacles to overcome in the recycling of waste oil. The first obstacle was that of an unfavorable tax on products made from used oil. The tax on certain recycled oils were higher than virgin oils. The second hurdle, product labeling, made any product blended with recycled oil display a label stating that it was made from previously used oil.

The most important hurdle according to Becker (197-) was consumer acceptance of recycled lubricating products. Recyclers need to prove consistent quality and value in recycled products for their market to grow.

Industrial consumers may be wary of recycled products for their own applications. Henke (1983, p. 310) warns that it is incumbent upon the user of reclaimed oil products to know the method of reclamation or re-refining and the organization. He says this avoids potential problems for the end user.

A significant increase in used oil recycling research was noted by Whisman and Ripley (1990) during the late 1970s and early 1980s. Used oil literature citations collected by NIPER jumped from 486 in 1979 to a total of 1203 in 1982.

Economic and environmental factors have caused sharp declines in the re-refining industry since 1982 (Whisman & Ripley, 1990). Lower crude oil prices make used oil recovery less attractive economically. One estimate (e.g., Canadian Association of Re-Refiners, 1987) places the level for economic recycling of used oil at a point where crude oil price exceeds $US30 per barrel.

Many of those watching the industry (e.g., Becker, 197-; Brinkman, 1987; Lubrizol, 1990) agree that economics play an important role in the oil recycling industry. Recyclers must compete with industrial users for the used oil. If the industrial user perceives burning used oil for fuel as a better economic value, then the recycling feedstock is reduced. Similarly, the finished basestock product of the oil recycler must compete with virgin lubricating basestock oil. Brinkman (1987) asserts that the oil recycler does not have control of either market.

Global events seem to influence the re-refining industry dramatically. Madhaven (1990, p. 54), illustrates the point by relating that hydraulic and lubricating oil prices, along with gasoline prices, were effected by the Persian Gulf War. The rising cost of these products was in addition to the escalating costs of disposal and handling liability.

The quality of the incoming feedstock also has an economic impact on the process. A wide variety of materials and contaminants found in used oil cause problems for the recycler. Chemical additives such as detergents and dispersants found in some industrial oils pose a more complex problem to remove from used oils. Fluids consisting of oil/water emulsions require more processing to recover than a straight petroleum base oil. Brinkman (1985) contends that better filtration techniques extend fluid life however, levels of contamination are greater when it is finally taken out of service. These factors increase the cost and complexity of recovery.

Used Oil Sources

Estimated volumes of all used oil generated in the United States have increased slightly over the last two decades. Becker (197-) put the volume of used oil generated in 1972 at roughly 1.1 billion gallons. Franklin Associates (Courtright, 1990, p. 81) estimated 1983 volumes at 1.16 billion gallons. In 1988, a study for the Environmental Protection Agency (EPA) by Temple, Barker and Sloane Inc., put the volume at 1.35 billion gallons (Courtright, 1990, p. 81).

Automotive oils make up the bulk of used oil generated each year. Industrial oils comprised approximately 37% of all the used oil generated in 1988, down from 39% in 1983. Courtright (1990, p. 81) sees the reduction as an apparent effort by industry to limit waste.

Information regarding the disposal of all used oil indicates that less than 2% was being re-refined (Courtright, 1990, p. 81; Lubrizol, 1991). The information also shows a tendency for a slightly over 50% of the collected oil to be used as industrial fuel and between 30% and 40% to be disposed of by landfill or dumping. The balance of used oil was used for other industrial purposes, road oiling or incinerated.

Whether automotive or industrial in origin, improper disposal used oil poses a substantial environmental danger. Dumping of a single gallon of used oil into the environment can contaminate millions of gallons of fresh water (Courtright, 1990, p. 81; Lubrizol, 1991).

The Governments Role

Federal legislation enacted in the 1970s by the federal government was intended to deal with two pressing issues; energy conservation and environmental protection. The Resource Conservation and Recovery Act (RCRA) of 1976 was drafted to govern the handling of waste materials. This law, also known as the Solid Waste Disposal Act of 1976, provides incentive to review the handling of solid waste by those responsible for its generation and processing. The law defines solid waste as gaseous, liquid or solid, or any variation of the physical state (Fawcett, 1984, p. 149).

The RCRA empowers the EPA to regulate the management of both hazardous and nonhazardous wastes. It also has provisions for financial and technical aid for work in the areas of energy and resource recovery (Fawcett, 1984, p. 149).

Fawcett also says the law plays a role in the shipping, handling and storage of wastes. Generators as well as transporters, disposers, treaters and storers of the material have certain responsibilities under the law. These stipulations increase the liability risk of transporting used oil for recovery purposes.

Environmental protection issues are increasingly important as society realizes its responsibility to preserve the earth notes Safety-Kleen (1991). They predict more restrictive laws regulating handling and disposal of waste oil with emphasis on generator responsibility.

The EPA and industry groups are currently involved in serious discussions over the future regulatory restrictions on used oil according to Lubrizol (1990). A court mandate directs the EPA to declare used oil a hazardous waste through a ruling expected sometime in 1992. The EPA has some latitude in establishing regulations and has sought input from the re-refining industry.

Many states have established used oil collection and recycling centers. There are 28 states with established programs, but only 19 are currently active (See Table 1). In the absence of an EPA regulation, seven states currently designate used oil as a hazardous waste (See Table 2).

Table 1

States with Active Recycling Programs

Alabama	Minnesota
California	New Hampshire
Connecticut	New York
Florida	North Carolina
Illinois	Oregon
Indiana	Rhode Island
Iowa	Vermont
Maine	Virginia
Maryland	Washington
Michigan	

Source: Lubrizol, 1991

Table 2

States which Classify Used Oil as Hazardous Waste

California	New York
Massachusetts	Rhode Island
Missouri	Vermont
New Jersey	

Source: Lubrizol, 1991

CHAPTER 3

TECHNICAL INFORMATION

Oils and Contamination

Lubricating Oil Composition

Virgin petroleum base lubricating oil products contain more than basestock oil. Chemical enhancers, known as additives, combine with the oil making it suitable for a specific application. (Madhaven, 1990, p. 56). Korane (1986, p. 51) explains that additives enable the oil to protect against rust, wear, foaming, emulsion formation, oxidation, and increase usable operating range. He also indicates that hydraulic fluid typically contains from .5% to 2% additives while multigrade oils contain up to 20% additives. Appendix C gives an overview of common lubricant additives.

Madhaven (1990, p. 56) reminds us that over a period of time additives are either physically removed or rendered ineffective through chemical reaction. Additive depletion causes a lubricating oil to loose the desirable operating characteristic it had originally.

One aspect of additive depletion is a rapid increase in oil oxidation. Fitch (1988, p. 5) describes conditions encouraging oxidation as heat, pressure, oil mixing with oxygen, and the presence of catalytic substances such as water and metal particles. Oxidation can become a self-propagating chemical process that will shorten the useful life of the fluid by producing sludges and resins (Cunningham, 1987, p. 29; Korane, 1986, p. 52; Madhaven, 1990, p. 55). The oil operating characteristics deteriorate and the oil must be removed or reprocessed (St. George, 1986).

Industrial oils are also subject to contamination from a variety of sources. Henke (1983) categorizes four sources of contamination in hydraulic systems as built-in, ingested, internally generated and maintenance generated. These sources may well apply to equipment using similar recirculating lubrication oil systems.

Water and silt contamination are two common factors which quickly reduce the lubricating qualities of an oil (Korane, 1986, p. 52). Water can cause silt particles to precipitate from the oil, producing viscous sludges. (Madhaven, 1990, p. 55).

Kimball (1975, p. 10) summarizes by saying that contaminants or impurities might include dust and fine metal particles in suspension as well as oxidation and decomposition products. Cunningham (1987) adds water as additional contamination factor.

Automotive oils do not typically constitute a major portion of the industrial used oil stream. However, their presence merits attention because of the contaminants they may contain. Used lubricating oil from the crankcase of gasoline engines contains some level of combustion byproducts from the engine fuel. The combustion of gasoline produces traces of heavy metals such as barium, lead and zinc in the used oil. (Becker, 197-).

Industrial Manufacturing Facility

The industrial facility in this investigation is a large agricultural manufacturing plant. Multiple buildings, several thousand machines, and a variety of manufacturing processes comprise the operation. It uses a number of petroleum base lubricating products in various quantities (See Appendix A).

No specific data has been collected to determine the relative composition of the used oil stream generated. Rather, it is assumed that the used oil stream is the result of normal maintenance and replacement of lubricating fluids in the facility.

Kimball (1975, p. 10) states that a significant quantity of oils purchased for internal use eventually exit as part of the used oil stream.

It must be noted the volume of purchased oil products do not directly correspond to the volume of used oil generated. Volume differences are attributable to fluids shipped with product, new equipment, process consumption, oil/emulsion products, spillage, leaks and other nonrecoverable losses.

The used oil stream from the industrial manufacturing facility contains many different types of used oil products. These products may include process fluids, cutting oils and oil emulsions, solvents, machine hydraulic and lubricating oils, vehicle operating fluids and crankcase oils (F.A. Van Schepen, personal communication, December 9, 1991). Equipment lubricating and hydraulic oils are the focus of oils in the investigation.

Current Disposal Method

The industrial facility in this investigation currently disposes of used oil through use as an industrial fuel. The commingled oil is gathered, treated and used as a fuel supplement, along with coal, in on-site powerhouse boilers. Free water separated from the mixture is treated and released for further processing. Appendix B describes the treatment procedure for the used oil.

Use as industrial fuel is effective from an economic, environmental and regulatory viewpoint. However, the next step in resource conservation is to return the used oil to useful service as a form of lubricant. Reduction in used oil generation should reduce disposal efforts and regulatory costs (F.A. Van Schepen, personal communication, December 9, 1991).

Processes

Overview

The intention of reclamation or re-refining processes is to return the lubricating oil to service in industry as a renewable resource. Cunningham (1987, p. 28) defines the function of filtration and reclamation as the removal of impurities so as to retain system operating characteristics. Re-refining, says St. George (1986), is a recycling method similar in nature to refining of crude oil.

It is prudent to pause and examine the waste stream of the industrial manufacturing facility in the investigation at this point. Recall that the waste stream is commingled, containing used oils of various quality and quantity and all forms contaminants. Clearly, this is not the proper handling for processes designed to separate useable oil from impurities. Chapter 4 deals with suggestion to improve this problem. The processes dealt with in this investigation assume that a more homogeneous feedstock is available for recovery.

The investigation first looks at two recovery processes that treat the oil in different manners. They restore used oil through less rigorous methods than re-refining. The oils produced by the processes are different and must be handled accordingly.

The technology used in the first method, adsorptive filtration, is mature and has been in use since recovery of used oil began (Brinkman, 1987). Electrostatic fluid cleaning is the second method and is relatively new. These methods may be used on-site however, dehydration and polishing stages may be necessary depending on feedstock and final product.

<u>Adsorptive (Active) Filtration</u>

Fitch (1988, p. 148) asserts that properly maintained fluid need not be reconditioned by re-refining or reclamation. He says current adsorption methods and additive replenishment effectively control contamination and its effects on the fluid

According to Cunningham (1987, p. 31) adsorption filtration depends on the level of molecular attraction between the filter medium and the contaminant. He explains that the adsorbent medium actively attracts a thin layer of contaminant molecules to its surface. The adsorbent may be a clay such as Fullers earth.

Cunningham continues by citing two adsorbent filtration methods currently used. In contact filtration, the adsorbent and used oil are mixed into a slurry. The slurry is then introduced into a filter press to remove the clay from the oil. The second method percolates oil through a filter bed of adsorbent medium, thus the name percolation method.

St. George (1986, p. 44) notes that active filters use adsorbents which remove the additives from the lubricant. The lubricant must be chemically reformulated with new additives before returning it to the same application.

Electrostatic Liquid Cleaning

Electrostatic liquid cleaning (ELC) systems remove suspended particulate contaminant from any non-conductive liquid. One electrostatic equipment manufacturer (Kleentek, 1990) claims to remove oxidation sludges and resins and particle contamination from 0.01 micron and up. The process is said to work with industrial products such as petroleum and synthetic base hydraulic fluids, lubricating oils (except engine oils) and transformer oils. Kleentek also states that the process does not remove soluble fluid components such as additives.

First applied to hydraulic fluids in the late 1960s, ELC functions as a recirculating cleaning system attached to a specific volume of fluid (See Figure 1). Dirty fluid is pulled from the application by a small pump in the ELC unit. It arrives at the bottom of the unit and is allowed to slowly flow up through a series of parallel plates (See figure 2). The plates are oppositely charged electrodes attached to a high direct-current (DC) voltage supply. A pleated cellulose media is positioned between the plates to increase the effective surface area for contaminant removal. The electrostatic field from the electrodes causes

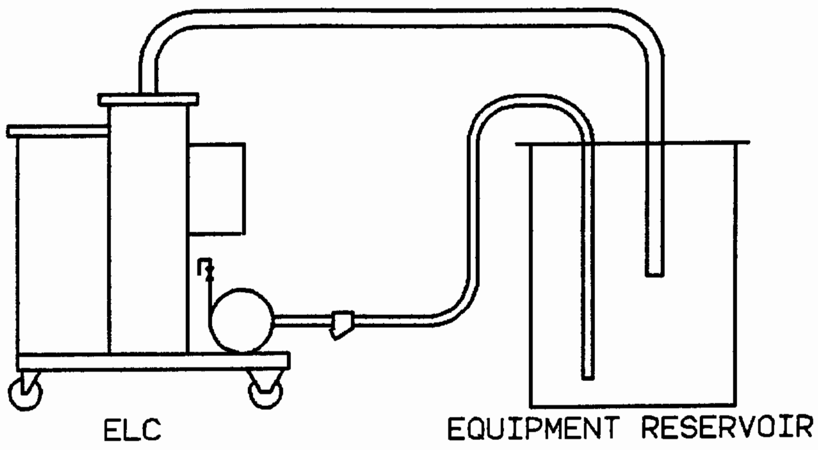

Figure 1. Recirculating method for Electrostatic Liquid Cleaning (ELC) system.

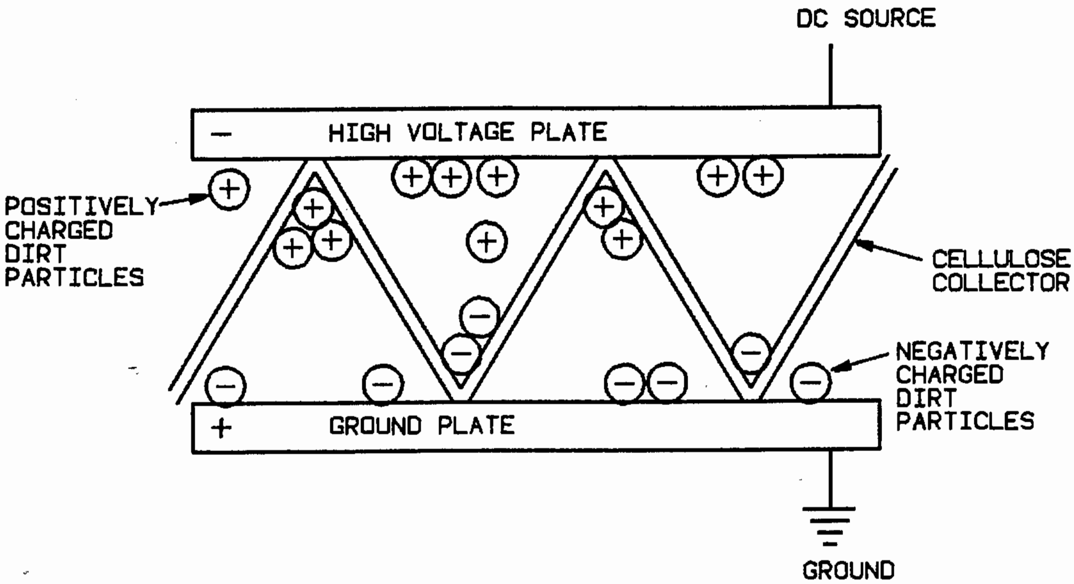

Figure 2. The Electrostatic Liquid Cleaning (ELC) system uses parallel electrodes and high DC voltage to attract contaminants.

suspended particles to be drawn to either electrode, depending on the natural charge or dielectric constant of the particle. As the particles approach the electrode, they hit and are trapped by the cellulose media. The media is removed and disposed of when dirty (Kleentek, 1990).

Fitch (1988) notes that electrostatic attraction can be an effective cleaning method if the fluid velocity is very low. This explains the positioning of the ELC in a recirculating loop where fluid velocity is independent of the equipment operation.

Distillation and Hydrotreatment Method

The last method is a re-refining process that produces base stock oil similar to the original refining operation. Re-refining removes any chemical additive packages along with contaminants. This requires re-formulating the oil with the appropriate additive packages for specific applications. The method also produces several other marketable by-products (See table 3).

One major re-refiner (e.g., Safety-Kleen, 1991) uses a four step re-refining process to return used oil to base oil stock. The steps are dehydration, fuel stripping, two-stage distillation, and hydrotreatment (See Figure 3).

Before entering the process, laboratory testing of the used oil determines suitability for re-refining. Chemical tests indicate the presence of polychlorinated biphenols (PCB's), total halogens, and heavy metals such as lead and zinc. The presence of halogens could indicates a possible mixing of chlorinated cleaning solvents with the used oil (J. Fayhey, personal communication, November 1991). Excessive levels of these compounds may make the used oil unsuitable for re-refining and more desirable as an industrial fuel.

The dehydration step takes place at an elevated temperature and atmospheric pressure removing water and light-end fuels. Next a fuel-stripping step at a higher temperature and moderate vacuum removes additional fuel from the oil.

Vacuum distillation vaporizes the oil in a thin-film evaporator (TFE) operating at a very high temperature vacuum. According to J. Fayhey (personal communication, November 1991) the TFE contains a rotating mechanism inside of a heated cylinder that sprays oil on the hot cylinder wall. The oil instantly vaporizes through flash evaporation and allows gravity

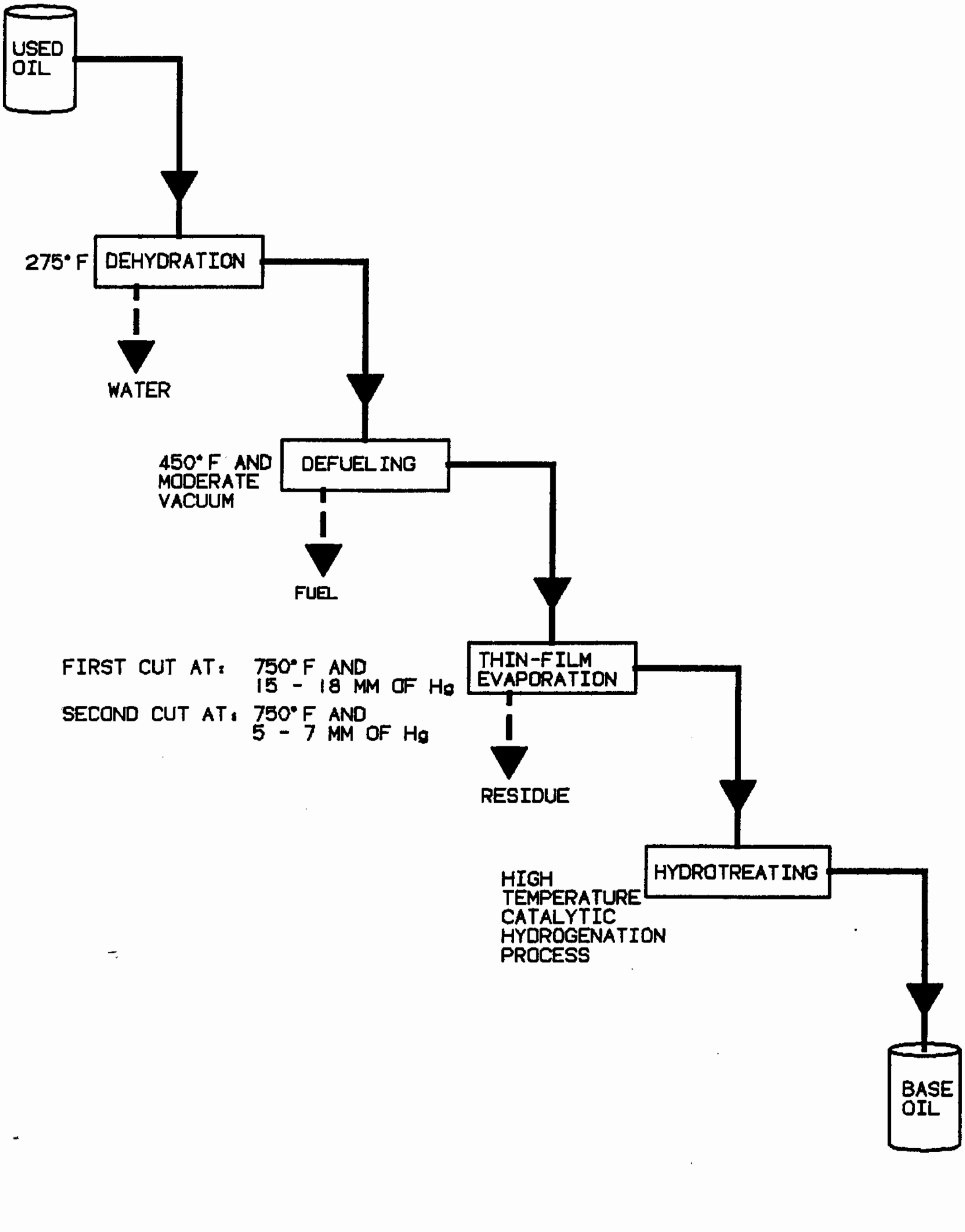

Figure 3. Schematic of distillation and hydrotreatment method.

to claim any heavy residue. Two distillation steps produce base oils with viscosities of 100 and 250 Saybolt Universal Seconds (SUS). The residuals that gather at the bottom of the TFE are primarily asphalt extender products.

Hydrotreaters stabilize hydrocarbon molecules in the oils by adding hydrogen atoms. The process removes sulfur, nitrogen, chlorine and oxygenated compounds by displacing the atoms with a hydrogen atom (Kerlin & Rabovsky, 1975, p. 67, 79). This high temperature, high pressure catalytic hydrogenation process also removes remaining impurities and heavy metals.

High pressure separators remove the hydrogen from the hydrotreated oil and a low pressure separator uses steam to remove light distillates from the oil. The hydrogen used in this stage of the process is recycled through a purification system which scrubs and compresses it for reuse in hydrotreating. (Safety-Kleen, 1991).

The process is relegated to off-site recovery due to equipment size and expense. The largest distillation and hydrotreatment re-refining facility in the United States (e.g., Safety-Kleen, 1991) has the capability to process 75 million gallons per year.

Brinkman (1987) indicates that distillation and hydrotreatment process is an effective means of oil re-refining. He notes the commercial feasibility of the process as important to long term success of re-refining.

Table 3

Products of Distillation and Hydrotreatment Method

Base stock oils are used to make:

- Formulated automotive oils
- Formulated industrial oils
  - Lubricants
  - Hydraulic oils
  - Cutting fluids

Industrial fuels[a]

- Fuel oil
- Light distillates
- Recycled used oil

Asphalt extenders

- For improving ductility of paving and roofing asphalt

[a] Approval of local standards and regulations required.

Source: Safety-Kleen, 1991

CHAPTER 4

CONCLUSION

Findings

Recovery techniques provide a means to clean used oil for some applications without massive re-refining. These methods provide a means for cleaning and polishing of oils, sometimes on site. Conversely, re-refining yields lubricating base stock oil products of very high quality and other marketable byproducts. The very nature of re-refining requires transporting the used oil off site.

Recovery techniques such as the ELC system have a place in maintaining lubricating oils for contaminant sensitive equipment. Their use is almost transparent to the normal operation of the manufacturing facility. They prolong the useful service life of the fluid and reduce the need for more extensive recovery methods.

Adsorptive techniques perform well but may not be applicable to use at the facility. Additional steps such as dehydration and polishing of the oil may be necessary. Chemical monitoring of lubricating oil may be necessary to maintain additives removed during the process. This may prove to be cost prohibitive unless significant volumes of common fluids are available for recovery.

Distillation and hydrotreatment re-refining returns useful basestock oil components of varying viscosities. These basestock products very nearly resemble the products of the original crude refining process. The use of TFE technology eliminates many of the harmful byproducts of older re-refining methods. Additionally the quality of re-refined oil products has seen great improvement.

Given current facilities, operating costs, government regulations and availability of virgin oil, the burning of used oil is probably the least costly alternative. However, the issue requires more than just a short-term economic analysis. Recovery of used industrial oil is an investment in the future. Resource conservation, pollution reduction and regulatory avoidance are but a few of the benefits possible. Industry will soon face new and more restrictive measures concerning waste generation. The time for action has come.

Recommendations

Areas for further investigation and study of this topic are as varied as the used oil feedstock to recover. A study of the generation volumes and quality of used oil from industry would be beneficial to estimate the economic impact. Additional work needs to investigate cost effective means of recovering cutting fluids and oil/water emulsions for industrial users.

Investigation into the use of alternative lubricating fluids could target vegetable-base fluids. A study of biodegradable fluids now popular in Europe may provide insight into their use here.

Used oil recovery causes some problems for the industrial facility. One such problem is the handling of the sludges and solids produced in the used oil waste stream. The facility must still provide a method of treatment and disposal for these heavy contaminants. The fuel content of this material is not high enough to burn on its own.

Investigative research needs to identify a means to make recycling more attractive from environmental and economic viewpoints. Industry incentives could provide the impetus to conserve resources.

Summary

Economic, environmental, regulatory, and technological problems influence the effectiveness of recovering used oil. These factors must be part of the decision to adopt a recovery plan for used industrial oils.

The quality and volume of the used oil feedstock and the desired lubricating oil produced help to determine a recovery system. Fluids, their operating properties and contaminants vary over a wide range and no single process is ideal for every purpose. Companies desiring to recover used oil must evaluate specific types and volumes of fluids and provide capital for handling and processing.

Corporate commitment and foresight are necessary in any endeavor where economic return is not immediately evident. Recovery of used oil has great potential to reduce dependence on virgin oil products and to limit our pollution and waste generation.

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Appendix A

Purchased Petroleum Oils

Appendix A

Purchased Petroleum Oils

A list of typical equipment lubricating oils for the industrial manufacturing facility in this investigation is provided below. This information is gathered from purchasing records for a rolling 12 month period (November 1990 - November 1991). The cumulative volumes are listed by broad application categories.

Type of Lubricating Oil	Gallons
Multi-Viscosity Motor Oil	1822
Automatic Transmission Fluid	6380
Hydraulic Oil	98151
Gear Oil	1515
Spindle Oil	2592
Miscellaneous Lubricating Oil	17112

Appendix B

Treatment for Industrial Fuel Use

Appendix B

Treatment for Industrial Fuel Use

This appendix provides a look at current disposal methods used by the manufacturer in this investigation in greater detail. Waste water treatment details are omitted for the sake of brevity. Information in this appendix is from a tour and conversation with an Environmental Engineer for the facility. (F.A. Van Schepen, personal communication, December 9, 1991).

Used oil is sent via truck, tank cart and pipeline to a waste treatment center located at the plant. Over 400,000 gallons per year of used oil from the facility are treated for use as industrial fuel. An additional 300,000 gallons per year is brought in from outside sources. The used oil brought in from outside sources is tested and their content must be recertified regularly.

The waste stream entering the treatment center is a wide variety of commingled industrial fluids. Appendix A lists some of the fluids that may eventually enter the process. Straight oils, oil/water emulsions and synthetic fluids are present in the used oil stream.

Gravity separates the solids and sludges to the bottom of the large receiving tank (See Figure 4). 300 to 500 gallons of the sludge is collected and added handled later in the process. The oil floats to the top and is skimmed off. The free water is separated and sent off for further treatment prior to discharge.

Oil Treatment

Skimming removes the oil from the top of the mixture and a pump transfers it to another settling tank. Tanker loads of waste from outside facilities joins the internal waste oil. Some water separates out and decanting removes it from the bottom of this tank.

A pump transfers the oily mixture into the 6000 gallon waste oil treatment tank. Sludge and solids from the first skimming operation join the oil in the treatment tank. The mixture is heated to 175 degrees F while adding a chemical emulsion-breaker to help separate water out of the mixture.

The treatment cycle begins when the mixture reaches 175 degrees F. The heating is discontinued and addition of a polymer compound to the mixture enhances the oil and water separation and to precipitate solids. Thorough mixing of the oil and polymer continues for

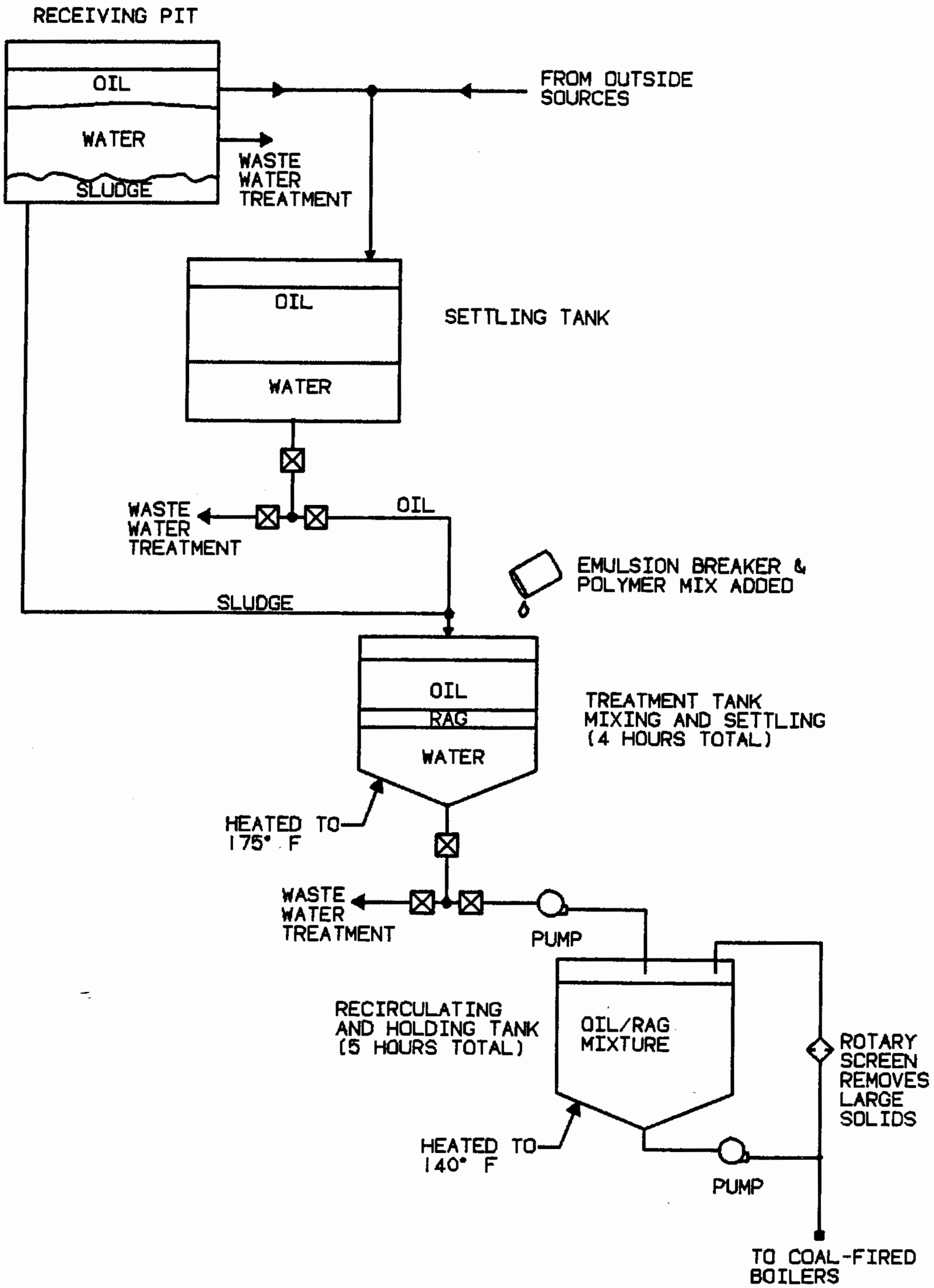

Figure 4. Schematic of current used oil disposal method for the industrial manufacturing facility.

about 20 minutes. An additional 20 minutes of very slow mixing insures that the oil and polymer are given a chance to chemically react. Mixing stops and the mixture is left to settle.

The mixture will settle into three phases. The water layer will be the bottom phase, an intermediate phase known as the rag layer is next. Composition of the rag layer is 40 to 60% oil, water and solids. The top phase contains mostly oil. Volumes of each phase vary with the composition of the used oil waste stream. Roughly 50% of the mixture is treatable waste water and about 25% as oil. The balance of the mixture is the intermediate phase or rag layer and other byproducts.

The sludge and solid wastes from the first skimming operation are difficult to process. Mixing them with the liquid oil waste, they end up as a significant component in the rag layer after treatment.

Before building the treatment center, the oil and rag layers were separated and each sent to an off-site facility for treatment. Now mixing the rag layer with the reclaimed oil allows use for industrial heating fuel. The rag layer has a fuel value of approximately 6,000 British Thermal Units per pound (BTU/lb), while the reclaimed oil is approximately 16,000 BTU/lb. The mixture of the two phases produces a resultant heating value of approximately 13,000 to 14,000 BTU/lb.

The power house co-fires their coal burning boilers with 10% to 15% waste oil. At this rate, the waste treatment facility provides the power house with 750,000 gallons per year of the oil and rag mixture. It is not possible to separate any of used oil wastes from one another with the current treatment facility. Design of the facility is for treatment of a commingled waste stream into an industrial fuel.

Appendix C

Industrial Lubricating Oil Additives

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Industrial Lubricating Oil Additives

The following are common lubricant additives found in industrial oils. (St. George, 1986).

Additive	Effect
Viscosity Index improvers:	Reduce the rate of change in fluid viscosity due to temperature change.
Detergents:	Combines with solid contaminants to prevent adhesion to moving parts also neutralizes oxidation acids.
Dispersants:	Keep small particles from settling out into sludges.
Antiwear agents:	Reduce wear between metal surfaces.
Oxidation inhibitors:	Reduce air/oil chemical interaction.

Additive	Effect
Rust inhibitors:	Protect against water corrosion and neutralize acids.
Antifoam agents:	Reduce surface tension.
Extreme-pressure agents:	Reduce wear under heavy loads.
Friction modifiers:	Reduce viscous friction.
Metal deactivators:	Protect nonferrous metals from effects of other additives.
Emulsifiers:	Increases oil/water mixing.
Demulsifiers:	Decreases oil/water mixing.
Pour point depressants:	Lowers range of oil liquid state due to temperature.
Dyes and stabilizers	Changes and controls oil color.

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