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Project Summary

Alternate Treatment of Organic Solvents and Sludges from Metal Finishing Operations—Final Report

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The objectives of this study were to (1) describe the metal finishing industry and its use of organic materials, (2) describe the quantity and composition of organic wastes from metal finishing, (3) describe the current technologies used to recover and dispose of these materials, and (4) draw conclusions and make recommendations on future work which needs to be done to improve ways to reuse or dispose of organic residues from metal finishing operations.

The metal finishing industry uses significant amounts of organic materials in its metal working processes, in solvent cleaning, and in product coating processes. Data on the quantities and compositions of these wastes were collected from literature sources, industry sources, and state and environmental agency files. Processes for handling these wastes were described and recommendations were made for future work to promote the safe disposal of these organic residues.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Industry Description

Metal Finishing

There are approximately 150,000 industrial plants in the United States in SIC Codes 25 and 33-39 which comprise the metal finishing industry.

This study of the metal finishing industry focused on processes which use significant amounts of organic materials. These are (1) the metalworking processes, (2) solvent cleaning, and (3) product coating processes. Metalworking processes are of four types: (1) metal removal, (2) metal forming, (3) heat treating, and (4) rust preventive coating. Specific processes included are listed in Table 1.

Some metal finishing processes, such as electroplating, primarily use inorganic materials. Examples of these processes, which are excluded from this study, are also shown in Table 1.

Metal cutting operations, such as machining, require oils both as lubricants and coolants. Emulsified oils or soluble synthetic fluids are sold as concentrates, then diluted with water before use. Metal forming operations use oils primarily for lubrication.

The hot- and cold-rolling operations used for production of steel and aluminum strip and sheet use many different types of oils. Heat treating operations, such as quenching, use mineral and emulsified oils to quickly reduce metal temperatures.

Table 1. Process Categorization

	Processes Included in Study	
Forming processes		*Cleaning processes*
Molding	*Drawing*	*Solvent cleaning*
Casting	*Rolling*	*Degreasing*
Shaping	*Stampling*	
Extruding		*Coating processes*
Abrasive processes		*Painting rust prevention*
		Rust prevention
Cutting	*Blasting*	
Boring	*Buffing*	*Heat-treating processes*
Grinding	*Deburring*	
Milling	*Polishing*	*Quenching*
Tumbling		*Tempering*
	Processes Excluded from Study	
Electroplating		*Surface preparation and post-treatment, including*
Etching		
Acid pickling		
Anodizing		
Bright-dipping		*Acid cleaning*
Passivating		*Alkaline cleaning*
Chromating		*Chemical machining*
Phosphating		*Chemical milling*
Plastic coating		*Chemical polishing*
Ceramic coating		*Chemical etching*
Immersion plating		
Galvanizing		
Conversion coating		
Alloying		

Straight mineral oils are used to coat steel coil as a rust preventive.

Degreasing or solvent metal cleaning uses nonaqueous solvents to clean surfaces of all of the common ferrous and nonferrous metals. The four main types of organic solvents used for solvent metal degreasing operations are: alcohols, halogenated solvents, hydrocarbons, and ketones.

Paints are classified in two major categories, as solvent-based or water-borne paints. The water-borne paints were developed to decrease the total amount of volatile solvent emissions and are widely used as product coatings. However, solvent-borne enamels and lacquers remain the most widely used in the automotive industry. Six major methods are used for the application of product coatings in the metal finishing industry: (1) spray painting, (2) dip coating, (3) flow coating, (4) roll coating, (5) electrodeposition, and (6) powder coating.

The purposes of this study were (1) to describe the metal finishing industry and its use of organic materials, (2) to describe the quantity and composition of organic wastes from metal finishing, (3) to describe the current technologies used to recover or dispose of these materials, and (4) to draw conclusions and make recommendations as to future work that needs to be done to improve reuse and disposal of organic residues from the metal finishing industry.

Organic Wastes

The annual quantities of organic materials used in metal finishing, the amounts of organic waste currently collected, and the estimated amounts that could be collected are shown below.

The oils may be petroleum-based mineral oils (used straight), emulsified oils, or synthetic oils. Commonly used additive types include anti-oxidants, rust preventatives, extreme pressure additives, viscosity index improvers, pour point depressants, fatty oils, and emulsifiers.

Waste mineral oils may contain sulfur, chlorine, fluorides, nitrogen, phosphates, metal chips and fines, sediment, water, PCBs, oxidation products, and phenolic compounds as contaminants.

Waste emulsified and synthetic oils may contain metal particles, biodegradation products, tramp oil, nitrosamines, and residues from oil additives — including sulfur, phosphorus, chlorine, zinc, lead, copper, and phenolic compounds — as contaminants.

The waste solvents may be halogenated or nonhalogenated and may contain oil, grease, wax, metallic particles, etc.

Waste coating may contain high concentrations of organic solvents, resins, and heavy metals.

Recovery and Disposal

Environmental regulations usually prohibit the discharge of untreated organic wastes from the metal finishing industry into surface waters because they contain unallowable concentrations of both organic and inorganic pollutants.

With increasingly restrictive environmental regulations, disposal of waste oils is becoming expensive. Therefore, refining/reclamation/alternate applications are viable options for waste oil generators.

Refining/reclamation technology for waste straight oils is well developed. Independent re-refiners accept waste oils for refining based on their composition and compatibility with refining technology used in their plants.

Waste emulsified oil treatment reclamation technology has been well developed in recent years. Economics of on-site or off-site treatment or disposal for a plant will depend on the volume of waste emulsified oil generated. Larger plants generally treat their waste prior to discharging wastewater to surface waters. Smaller plants exercise off-site treatment or disposal options. It is possible that some plants might still be illegally disposing of waste emulsified oil into sewers. The use of regional facilities to treat waste emulsified oils from small plants has been considered.

Synthetic fluids are expensive, so fluid maintenance and management programs in the plant are utilized to increase fluid life expectancy. Very limited technology is available at present to reclaim spent synthetic fluids. Synthetic fluids manufacturing firms are developing water soluble biodegradable synthetic fluids to

Use	*Annual consumption, 10^6 kg/yr*	*Waste collected, 10^6 kg/yr*	*Waste potentially collectable, 10^6 kg/yr*
Metalworking (oils)	*760*	*180*	*480*
Degreasing (solvents)	*670*	*580*	*630*
Product coatings (paints)	*1,050*	*200*	*200*
TOTAL	*2,480*	*960*	*1,310*

avoid costly disposal problems. Disposal alternatives and costs are highly dependent on the chemical formulations of synthetic fluids, which are generally treated as proprietary information. For this reason, very limited information is available about treatment or disposal of spent synthetic fluids.

Waste solvents have high potentials for recovery and reuse. Also the Resource Conservation and Recovery Act (RCRA) lists waste solvents as hazardous waste, so they are to be disposed of in accordance with the regulations.

Reclamation technology for waste solvents is well developed. Due to RCRA regulations, disposal of waste solvents is becoming very expensive. For this reason more generators are starting to use the services of waste solvent reclaiming firms. Waste solvent reclaiming firms have been growing in number since RCRA regulations came into effect.

The major application method contributing to paint waste is the spray coating method. The waste is almost exclusively disposed of in either sanitary or secured landfills. A very small portion is incinerated.

Paint wastes have limited recovery or reuse potential. Waste coating may or may not be a hazardous waste depending on its composition. The disposal practice will depend on whether the waste is hazardous or nonhazardous. RCRA testing will be required to classify a waste coating as hazardous or nonhazardous.

Conclusions

From this work it was concluded that:

(1) The 150,000 metal finishing plants in the United States use 2,480 million kilograms of organic materials per year

(2) At present approximately 40 percent of these materials are collected for reclamation or disposal by processes such as incineration, landfill, or use in road paving. The other 60 percent which is not collected, is disposed of by processes such as vaporization losses, process losses on-site, and dumping.

(3) The metal finishing industry is concentrated in ten heavily industrialized states. California, Illinois, New York, Ohio, Michigan, Pennsylvania, Texas, New Jersey, Massachusetts, and Indiana (in order of number of large plants).

(4) These states are the ones with the most potential for setting up reclamation centers since they generate the largest amount of wastes.

(5) The organic wastes from the metal finishing industry come primarily from the metalworking, solvent cleaning, and product coating processes.

(6) The wastes from the metalworking and solvent cleaning processes generally contain sufficient concentrations of organic or inorganic contaminants to make them environmentally unacceptable for discharge to surface waters without treatment.

(7) Paint wastes vary from innocuous to hazardous; hence, decisions must be made on each one individually to determine whether or not there are restrictions on the manner in which they are disposed of.

(8) Waste oil compositions vary considerably, depending upon their initial composition, the process in which they are used, the severity of the operating conditions (temperature and pressure), and the degree of recycle or reuse.

(9) Waste mineral oil refining and reclamation technology is well developed technically, but its economic practicality is in question. At present only a small fraction of the oil which could be re-refined is processed for reuse. The relatively small volume of oil being processed and its fluctuating quantities produce uncertainty in the economic viability of this approach. As long as there are few regulations requiring or strongly encouraging re-refining, it will continue to be a solution for only a small fraction of oil disposal problems.

(10) The costs of disposing of waste oil are increasing, making re-refining or reclamation more attractive economically.

(11) High-priced synthetic metalworking fluids are increasingly used in the industry. The recovery potential for synthetic fluids is unknown at present.

(12) Few reclaimers handle waste oil water emulsions, or synthetic or water-based metal working fluids.

(13) Solvent recovery is handicapped by the diversity of solvents available and the small quantities of specific solvents at some locations. Some solvent recovery companies are not well qualified, and they are frequently underfinanced.

(14) Some solvents are complex mixtures of chemicals that are difficult to recycle.

(15) Disposal companies are basically incinerating waste solvents at high cost. Disposal costs are so high that waste solvent generators are reluctant to call them.

(16) Most solvent recyclers only process a limited number of solvents. They may not provide a service to many small waste solvent generators.

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The complete report, entitled "Alternate Treatment of Organic Solvents and Sludges from Metal Finishing Operations—Final Report," (Order No. PB 84-102 151; Cost: $28.00, subject to change) will be available only from:
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