Soy Metalworking Fluid

Company A

New Environmental Technology for Small Business (NETSB) Project Summary

NETSB, a program developed by the Iowa Waste Reduction Center (IWRC) at the University of Northern Iowa, strives to increase the use of new environmental pollution prevention technology by small business, resulting in measurable environmental and economic benefits.

When choosing which technologies to test, the IWRC recognized three key areas of consideration: environmental criteria, economic measures and small business use feasibility. The equipment should have a positive impact on the environment, such as pollution prevention or energy savings. The technology should be evaluated considering capital costs, operational costs and return on investment. And finally, the equipment should be applicable in a small business environment.

In 2006-2007, the IWRC placed several types of potential pollution prevention technologies at small businesses throughout Iowa including: soy-based metal working fluids, RASERS heat reclamation equipment, and Zerowaste wastewater treatment systems.

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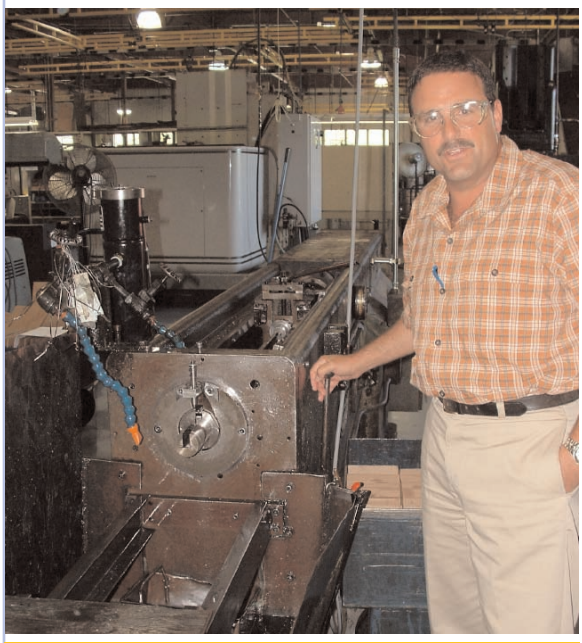
Small Business Placement Description

Company A is a custom manufacturer of various types of gears, sprockets, couplings, clutches and shafts. The company is also a supplier of parts for transmission units and manufactures decorative fireplace furnishings.

The broach operation at the facility uses both petroleum-based coolant and neat oil in the same broach machine. The coolant is used because it easily enters the small threads of the broach and the neat oil is also used because it allows for the intricate cuts needed. But using both types of fluids costs the facility dearly in labor hours spent switching between the two types of fluids and maintaining the machine. The facility agreed to test a soy-based product and the petroleum-based fluids were replaced with a soy-based neat oil alternative (Soy Easy Uni-Cut) in April 2006.



In May 2006, the facility also agreed to test a soy-based product in its cast iron machining operation. Petroleum-based neat oil was replaced with the soy alternative Soy Easy NuCut Plus.

Nearly a year after initial testing, the facility reported the Soy Easy Uni-Cut neat oil to be performing wonderfully in the broach operation. The soy-based neat oil worked perfectly for both needs in the operation, eliminating the need to clean out the machine and use two types of petroleum-based fluids.

The facility also reported the cast iron operation, which typically experienced rancidity issues with petroleum-based neat oil, was running well. The facility also decided to try the soy-based neat oil in its shaper, which it reported was working just as well, if not better than with the petroleum-based product.

Technology Description

Several steps are necessary to convert metal stock into useful metal products. These steps are conducted by businesses in the metal working industries; specifically described by Standard Industrial Classification (SIC) Codes 3400-3499.[1]

The fabricated metal industry shapes products from stock material through one or more machining processes. Machining

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operations require the use of tools to refine the shape of the work piece by removing small amounts of material from it. Examples of machining processes include drilling, milling, turning, planning, sawing and grinding. Machining processes use various products such as cutting fluids, lubricants, hydraulic fluids, cooling or quench oils, and cleaning solutions.

Machining involves high-pressure, metal-on-metal moving contacts between tool and work piece. To reduce the heat and friction caused by these operations, MWFs are circulated over the work surface. These fluids are used to:

- Control and reduce the temperature of tools and work surfaces;
- Reduce friction and vibration by acting as a lubricant;
- Wash away chips and metal debris;
- Improve the quality of the machined surface; and
- Inhibit corrosion and rust on newly exposed surfaces.

In addition to MWFs, many machines require hydraulic fluids and lubricants that frequently leak into the work area and may contaminate MWFs. Eventually MWFs become spoiled or contaminated and must be replaced. The heat generated during the shaping process can degrade MWFs or cause a loss of water and degradation of additives. Bacterial growth may cause contamination and lead to fluid deterioration as well.

Metal working fluids are divided into two types: water-soluble coolants and neat (straight) oil.

Petroleum-based water-soluble coolant is the most common MWF used in industry. Water-soluble coolants are generally comprised of 5% cutting fluid and 95% water and are used in processes that require a bath of product to continually remove shavings or grind away from the part being machined. Water-soluble coolants also improve cooling capabilities.

Some severe cutting operations require the use of neat oil. Neat oil is 100% product and does not contain water. Some petroleum-based neat oils contain additives such as sulfur and chlorine that act as wetting or extreme pressure agents. Unlike water-soluble coolants, neat oil offers excellent lubricity, longer tool life, rust protection and extended oil life.[2]

Soy-Based Metalworking Fluids

The use of soy-based fluids for metalworking began as an alternative to conventional products (petroleum-based, synthetics and semi-synthetics). Soy-based MWFs, like many other agriculture-based fluids, exhibit superior lubricity in many industrial applications. Additionally, many companies are interested in products that are developed from renewable resources that help agribusiness. Specifically, soy-based MWFs may exhibit some or all of the following advantages over conventional petroleum-based products:

- Produce less smoke and mist resulting in

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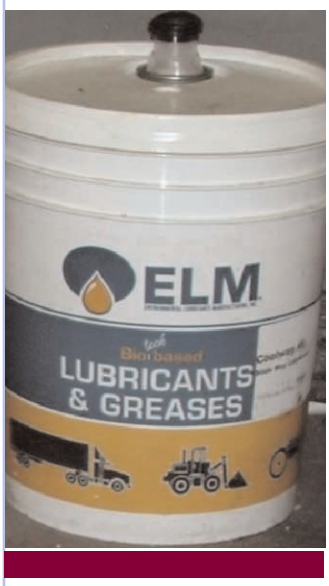
reduced inhalation problems;
- Contain no chlorine or sulfur, both regulated substances;
- Eliminate dermatitis issues;
- Reduce retooling costs; and
- Increase productivity.



Soybean oil has a higher molecular weight, a higher flash point and lower volatility when compared to petroleum oil. These properties help soy-based MWFs bond well with metals, serving as an effective friction reducer (lubricant). Reduced wear on tools and machinery enhances the longevity of these durable goods. Vegetable oil-based MWFs may be less toxic and may reduce disposal costs when compared with conventional petroleum-based fluids.[3]

The products placed at the facility were Environmental Lubricants Manufacturing, Inc. (ELM) SoyEasy Uni-Cut and SoyEasy NuCut Plus neat oil alternatives.

Environmental Background

It's estimated over 1 billion gallons of MWFs are used every year.[4] Eventually MWFs spoil or become contaminated and must be replaced. Waste MWFs are harmful to the environment because of high oil content, biochemical oxygen demand, high concentration of surfactants and because they may carry other hazardous metals and chemicals.[5] Waste fluids are subject to rule under the Resource Conservation and Recovery Act (RCRA). The treatment and disposal of spent MWFs can comprise up to 15% of the total machining costs at an average machining facility.[6] Other machining wastes include metal fines and oily wastewater.

Soy-based MWFs are industrial products that come from a renewable resource. Using soy-based products inadvertently guides companies away from the controversies, pollution, energy consumption and waste generated during the extraction,

Environmental Lubricants Manufacturing, Inc. "Soy Easy® Unicut Soy-Based Cutting Oil." Nov. 2006. http://www.elmusa.com/products/data_sheets/pdf/soyeasy_unicut.pdf

Environmental Lubricants Manufacturing, Inc. "Soy Easy® NuCut Plus ™ - Soy-Based Cutting Oil" Nov. 2006. Material Safety Data Sheet: http://www.elmusa.com/products/data_sheets/pdf/soyeasy_NuCut_Plus.pdf

http://www.elmusa.com/products/msds/pdf/soyeasy_NuCut_Plus_msds.pdf

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transportation, use and disposal of petroleum products. The use of biochemicals, such as soy, may reduce upstream and downstream pollution.[7]

Health & Safety Background

According to the National Institute for Safety and Health (NIOSH), more than 1 million workers (including machinists, mechanics, metal workers and machine operators) are exposed to petroleum-based MWFs in the United States. Primary exposures to petroleum-based MWFs occur through exposed skin contact or inhaling/ingesting particles, mists and/or aerosols.[8] Exposure to conventional petroleum-based MWFs are known to contribute to several health concerns including:

- Irritant or reactive dermatitis due to removal of natural protective oils in the skin; [9]
- Folliculitis due to repeated skin exposure;
- Decreased lung function due to repetitive inhalation of aerosols; and
- Increased occurrence or worsening of respiratory diseases such as asthma, bronchitis and hypersensitivity pneumonitis due to inhalation of mists.

Components of petroleum-based MWFs such as formaldehyde are known irritants to the eyes, nose and throat. Additives have long been blamed for increased cancer risk and irritant or reactive dermatitis. Constituents of petroleum-based MWFs like glycol ethers and pentachlorophenol may cause birth defects or decrease a worker's ability to have children.[8] Several studies summarized by NIOSH also indicated an association between petroleum-based MWF mist exposure and cancers, including cancer of the larynx, rectum, pancreas, skin, scrotum and bladder.[3]

Finally, misting of soluble petroleum-based MWFs during machining processes can contribute to an unsafe working environment by making floors and work surfaces slippery.

Animal studies have shown that exposure to vegetable oil-based MWFs may cause fewer health concerns than petroleum-based fluids. When mineral and vegetable oils were injected directly into animal lungs, the body removed the vegetable oil slowly over several months. However the mineral oil caused slight fibroses of the lung and was still observed in the body after 2-3 months. Additionally, after mice were exposed to vegetable, animal and mineral oil mists, the vegetable and animal oils were removed from the lungs within 4 days, but the mineral oils mostly remained in the lungs.[10]

The health and safety benefits of soy-based MWFs also include reduced dermatitis issues. Soy-based MWFs superior adhesion properties may reduce the occurrence of misting. Reduced misting results in a decrease of inhalation-related health problems and creates a safer work environment by reducing slippery floors and work surfaces.

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It is becoming more widely accepted that businesses may improve working conditions and decrease health and safety concerns by using bio-based products. Plant-derived chemicals are usually lower in toxicity, flammability and corrosivity when compared to their petroleum-based counterparts.[7]

Outcomes

POLLUTANT REDUCTION OUTCOMES

Every industrial process has inputs and outputs. Material that is not incorporated into the finished product eventually becomes waste. Implementing pollution prevention can increase industrial efficiency and potentially decrease costs.

The company was able to reduce its non-hazardous oil disposal from 6,000 gallons/year to 500 gallons/year.

ECONOMIC OUTCOMES

Increased product life is the most significant economic benefit of this pollution prevention application.

The cost of fluid divided by its life expectancy is the best calculation of the true cost of metalworking fluids. Although petroleum products may cost less per gallon than soy products, the increased lubricity and durability of the product greatly enhance the economic benefit of using soy metalworking fluid.

Cost of 55 gallons
Soy Easy Uni-Cut $632.50

Cost of 55 gallons
Petroleum-Based Product $467.50

Lifespan in Months for
Soy Product 10

Lifespan in Months for Petroleum
Product 1

Annual Purchasing Costs for Soy
Products $5,750.50*

Annual Purchasing Costs for Petroleum
Products $51,000.00**

Annual Disposal Cost for
Soy Product .....$750.00+

Annual Disposal Cost for Petroleum
Product .....$9,000.00++

Total Annual Cost for Soy Products.....$6,500.00

Total Annual Cost for Petroleum Products.....$60,000.00

Total Annual Savings with soy Products.....$53,500.00

**$632.50/55 gallons x 500 gallons/yr = $5,750.00*

***$467.50/55 gallons x 6,000 gallons/yr = $51,000*

+$1.50/gallon x 500 gallons/yr = $750.00

++$1.50/gallon x 6,000 gallons yr = $9,000

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The economic analysis above does not include the added savings the soy product provides in decreased labor hours spent by employees cleaning out the broach machine to switch back and forth between petroleum-based coolant and neat oil. Because the soy neat oil works well for both jobs, it does not need to be removed. The company estimates it saves $275 for each time the machine would have needed maintenance.

TECHNOLOGY ACCEPTANCE AND USE OUTCOMES

The company expressed high satisfaction with the soy products tested. It became evident during testing that the soy products work just as well or better at all applications as the petroleum-based products. In addition, the facility was able to see tangible cost savings in purchasing raw product, decreased disposal fees and decreased labor costs due to machine maintenance.

The facility will continue purchasing soy-based neat oil in the future.

ACRONYMS USED IN THE CASE STUDY

ELM .....Environmental Lubricant Manufacturing, Inc.

IWRC ....Iowa Waste Reduction Center

MWF.....Metal Working Fluid

NIOSH .....According to the National Institute for Safety and Health

RCRA.....Resource Conservation and Recovery Act

SIC .....Standard Industrial Classification

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