

# Soy Metalworking Fluid



Company B

“ **The shop realized a 20-30% increase in productivity and cut retooling costs 50% by switching to soy oil** ”

## 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.

A manufacturer of screw machine products and turned parts located in southern Iowa,

began testing soy neat oil in Spring 2006. The shop was interested in trying soy metal working fluids to close the loop as a supplier to agribusiness.

## Small Business Placement Description

Soy metal working fluid replaced straight petroleum oil in several test machines. As the test period proceeded, additional machine stations were converted to soy oil. The shop has a central reservoir system so the test machines were isolated to ensure that no soy neat oil was mixed into the central system and no petroleum make up oil was added to the test stations. The machines were single and multi-spindle stations. An immediate increase in tool life (or reduction in retooling) was identified.

The product placed was Environmental Lubricants Manufacturing, Inc. (ELM) SoyEasy UNI-Cut™, a universal cutting, way, and hydraulic fluid. Formulated with the best-optimized USA-grown natural seed oils and select additives, it surpasses the lubricity and performance of conventional metalworking fluids.<sup>1</sup>

As the test period continued, the machine feed rates were increased at each station. A minimum increase in feed of 20% was verified with some machines increased to 30% higher productivity than when using petroleum oils. Overall an average of 25% increase in feed rate (productivity) was realized.

Additionally, a noticeable reduction in the number of retooling events for each station was documented. Previously, using petroleum neat oil, each spindle had to be retooled twice per day for about 15 minutes of downtime. Using soy oil the frequency was cut in half, resulting in only one retooling event per day. This reduction in retooling further increased productivity as well as cut the cost of retooling by 50%, potentially saving over \$66,000 per year.

Environmental Lubricants Manufacturing, Inc is the leading provider of bio-based lubricants and greases in the United States. These products are based on exclusive biotech-based technology, formulated with renewable, biodegradable USA-grown vegetable oils. These lubricants, greases, and metalworking fluids are environmentally friendly and meet or exceed industry standards.<sup>5</sup>

<http://www.elmusa.com/>

The shop decided to make full conversion to soy oil based on the a 20-30% increase in productivity and 50% reduction in retooling costs. The cost for complete conversion was \$23,000. The petroleum oil could have been consumed but the shop was anxious to complete the conversion to soy to realize the increased productivity and reduced tooling costs as soon as possible.



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## Technology Description

Metal working fluids basically come in two types: water-soluble coolants and neat (straight) oil. Neat oil is required for difficult processes that require the highest level of lubricity. Neat oil is the most expensive metal working fluid due to the high volume of product used. Therefore, it is only used in shops when specialty work requires it.

The use of soy oil for metalworking began as an alternative to conventional products (petroleum-based, synthetics and semi-synthetics). Soy oil, like many other ag-based oils, exhibits superior lubricity in many industrial applications. Additionally, many companies are interested in biodegradable products, especially those developed from renewable resources that help agribusiness. Specifically, soy oils have the following advantages over conventional products:

- 1) produce less smoke and mist for reduced inhalation problems
- 2) contain no chlorine or sulfur
- 3) reduce or eliminate dermatitis issues
- 4) reduce retooling costs
- 5) increase productivity (or feed) rates.

Several steps are necessary to convert metal ores into useful metal products. These steps are conducted by businesses in the metal working industries; specifically classified by Standard Industrial Classification (SIC) Codes 3400-3499.<sup>2</sup>

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

shaped by using heat-treating or cold pressure methods. Cold pressure methods shape the work piece by applying direct physical pressure to cold metal. Shaping operations include shearing (e.g. punching), forming (e.g. spinning or drawing), and machining processes. Machining operations require the use of machining tools to refine the shape of the work piece by removing small amounts of material. Examples of machining processes include drilling, milling, turning, planing, sawing and grinding. Machining processes use various products in the processes such as cutting fluids, lubricants, hydraulic fluids, cooling or quench oils, and possibly 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, metal working fluids (MWFs) are circulated over the work surfaces. 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.

## Environmental, Health, and Regulatory Background

Neat oils contain additives to improve performance and inhibit rust and corrosion.

Traditionally, petroleum products contain wetting agents to increase lubricity as well as extreme pressure additives such as sulfur and chlorine.<sup>3</sup> These additives enhance the anti-welding properties and improve lubrication. However, neat oils have poor heat dissipating properties and therefore, increase fire risk. They may also create smoke in the shop that results in a poor work environment. Petroleum oils can cause folliculitis and oil acne by blocking skin or hair follicles.<sup>4</sup>

Soybean oil has a higher molecular weight and flash point when compared to petroleum oil. These properties help soy oil bond well with metals serving as an effective friction reducer (lubricant). They also decrease heating, minimizing smoke and mist problems by not burning off at high temperature points such as the tool-to-part contact point. Soy oil also includes reduction or elimination of dermatitis due to its compatibility with natural skin oils and the lack of harsh chemical additives.

One of the most obvious environmental benefits of soy is that it's a biodegradable product that comes from a renewable resource.

Using straight oils for machining in this shop eliminated spent metalworking fluids as a

**“The reduced wear on tools and machinery is an environmental benefit by enhancing the longevity of these durable goods.”**

waste stream since all of the product (whether soy or petroleum) is consumed in the process. During the conversion from petroleum-based MWFs to the ELM soy product, used oil was generated. The used metalworking fluid was recycled by a local used oil marketer under the Used Oil Management Standards (40CFR279).

Disposal is not usually an issue with the neat oil in this shop. The central reservoir system is equipped with a centrifuge that removes the metal fines and continually recycles the oil. The soy oil is being used in the same recovery system without any modification. The metal fines are recycled.

## Outcomes

### POLLUTANT REDUCTION OUTCOMES

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

The shop's increase in productivity by an average of 25% equates to a reduction in material usage of 5,000 pounds per year.

### ENVIRONMENTAL & HEALTH OUTCOMES

The health and safety benefits of soy MWFs include reduced dermatitis issues and reduced smoke that causes inhalation problems. Soy oil's superior adhesion properties also reduce safety concerns by not creating slippery work surfaces.

Substitution of a petroleum product with a biodegradable product manufactured from a renewable resource that benefits agribusiness has many known environmental benefits. "Businesses can improve the work environment for their employees by using biochemicals and thus reduce health and safety risks. Plant matter-derived chemicals are typically lower in toxicity, flammability and corrosivity than their petrochemical counterparts."<sup>5</sup>

### ECONOMIC OUTCOMES

Increased productivity and reduced retooling costs are the most significant economic benefit of this pollution prevention application.

The cost benefit analysis provided on the following page is an extrapolation for an entire production year based on the data collected during the test period. The shop rate was based on an average rate for the industry.

Cost of Petroleum Product.....\$6.49 per gallon  
 Cost of Soy Product.....\$11.53 per gallon  
 Assumes the shipping costs are the same .....  
 Average shop hourly rate .....\$75.00  
 System capacity .....1500 gallons  
 Annual make up.....1000 gallons

Cost of Petroleum MWF annually at \$6.49 per gallon .....\$16,225.00  
 Retooling cost annually with petroleum .....\$132,300.00

In-house sharpening of high-speed circular form tools was conducted twice per day for about 15 minutes for each spindle (40) on 252 production days per year. 0.25 hours X \$75 shop rate X 40 spindles X 252 days = \$132,300

**Annual cost of using petroleum at baseline production rate .....\$148,525.00**

Cost of Soy MWF annually at \$11.53 per gallon.....\$28,825.00  
 Retooling cost annually with Soy (doubled the life of the tools) .....\$66,150.00

**Annual cost of using soy .....\$94,975.00**

**Annual savings of using soy MWF .....\$53,550.00**

Estimated increased productivity by 25% .....\$1,058,400.00

Eight (8) hours shifts X One (1) shift per day X 252 production days per year  
 X the average shop rate of \$75 per hour X Number of machine stations X  
 25% =

**Projected total cost savings & estimated increase in productivity ....\$1,111,950.00**

## ACRONYMS USED IN THE CASE STUDY

CNC .....Computer Numerical Control

ELM .....Environmental Lubricant  
Manufacturing

IWRC ....Iowa Waste Reduction Center

MWF .....Metal Working Fluid

SIC .....Standard Industrial Classification

## References

- <sup>1</sup> [http://www.elmusa.com/products/data\\_sheets/pdf/soyeasy\\_unicut.pdf](http://www.elmusa.com/products/data_sheets/pdf/soyeasy_unicut.pdf) located on the manufacturer's website at <http://www.elmusa.com/index.html>. For the Material Safety Data Sheet see [http://www.elmusa.com/products/MSDS/pdf/soyeasy\\_unicut\\_msds.pdf](http://www.elmusa.com/products/MSDS/pdf/soyeasy_unicut_msds.pdf).
- <sup>2</sup> Guyer, Howard H., Industrial Processes and Waste Stream Management. John Wiley & Sons, Inc. 1998, Chapter 14.
- <sup>3</sup> Cutting Fluid Management for Small Machining Operations: A Practical Pollution Prevention Guide, 3rd Edition. Iowa Waste Reduction Center, 2003. <http://www.iwrc.org/downloads/pdf/cuttingFluid03.pdf>.
- <sup>4</sup> "Prevention of Skin Problems when Working with Metal Working Fluids" Technical Report 55-7-2001, July 2001. Washington State Department of Labor and Industry. [http://www.lni.wa.gov/Safety/Research/Dermatitis/files/mwf\\_skin.pdf](http://www.lni.wa.gov/Safety/Research/Dermatitis/files/mwf_skin.pdf).
- <sup>5</sup> Institute for Local Self-reliance website for The Carbohydrate Economy Clearinghouse at <http://www.carbohydrateeconomy.org/html/biochem.htm#anchor2>.