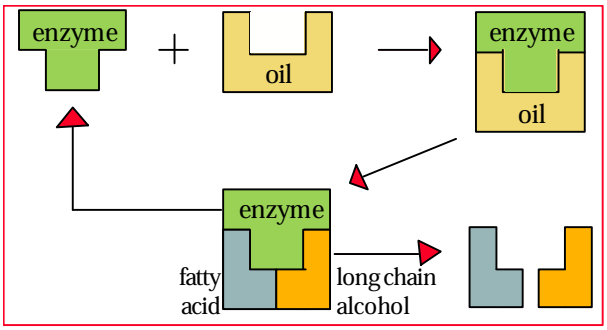
Enzymatic Cleaning

Cleaning by Enzyme Action

Overview of the Technology

The enzymatic cleaning method makes use of enzymes in water to break down grease and oil into permanently water-soluble fatty acids and long chain alcohols. In contrast, detergent-type cleaners simply emulsify oil and grease into temporary mixtures of oil droplets in water. When operated properly, an oil film will not develop on the surface of an enzymatic cleaning bath. This is an advantage over typical aqueous cleaners because there is no need for oil skimming equipment and it may be possible (with approval from the appropriate authorities) to directly discharge spent baths to a sewer. After rinsing, the parts are typically free of residual oil and grease. As with any cleaning operation that excels at removing oil and grease, parts capable of rusting must be quickly treated with rust inhibitor to avoid flash rusting after rinsing.

Schematic of Chemical Reaction



Because the removal of oil and grease by enzymes is a chemical reaction, there is an optimal temperature for best enzyme action. Agitating the solution increases enzymatic cleaning action since it keeps fresh enzymes in contact with oil and grease at the surface of the part. Agitation also keeps the solution well oxygenated. This is necessary for full decomposition of oils and greases.

How Enzymatic Cleaners Perform

The specific enzyme cleaner evaluated by NC3R was CJ's Parts Washing Solution, manufactured by Latta Biotechnology. This chemistry is reported to have an optimum cleaning activity around 125-130° F. Compared to typical aqueous cleaners, this is a relatively low temperature and translates into lower energy costs. Above 135° F the enzymes themselves begin to break down. At temperatures below the optimum the chemical reaction slows, thereby slowing the cleaning process.

Like any cleaner, the enzyme solution can become saturated with oil and grease. A simple test was performed to determine the loading limit with the CJ's enzyme cleaning solution. Small quantities of motor oil were added over time to a 16% concentration enzymatic cleaning solution at 125° F. The enzymes were able to break down oil equivalent to 14% of the initial volume of cleaning solution before the solution developed a persistent oil layer on the surface. Restated, a 30-gallon tank of cleaning solution can break down 4.2 gallons of oil before reaching saturation. At saturation, the solution is no longer effective.

Enzymatic cleaning baths can turn bad in much the same way that water-based machining coolants go rancid. A 16% enzymatic cleaning solution that is aerated by daily use in an agitated tank will last at least 8 weeks without going rancid.

Enzyme cleaning chemistry can be used in a variety of cleaning equipment. Four types of equipment were evaluated by NC3R: manual cleaning using brushing, agitated immersion, ultrasonic cleaning, and vibratory cleaning. (The test results for vibratory cleaning with enzymes will be reported in NC3R's upcoming Vibratory Cleaning fact sheet.) The working concentration used in all cases was 16% in tap water.

Enzymatic Cleaning

Agitated Immersion with Enzymes

For this evaluation NC3R used equipment consisting of a recirculating pump with an in-line heater and a 15-gallon tank. The pump discharge was configured to produce a relatively fast whirlpool and parts were placed inside the whirlpool. The in-line heater could only reach a stable maximum temperature of 110° F, which is not optimal for this cleaning solution. Automotive parts cleaned in this process had varying results. Parts with very heavy layers of grease such as CV joints were still greasy after an immersion time of 90 minutes. Parts with light layers of oil, such as the internal components of fuel pumps, were oil-free after 60 minutes of agitated cleaning.

Ultrasonic with Enzymes

The ultrasonic equipment used in combination with the CJ's Parts Washing Solution was a CAE Ultrasonics benchtop tank, model HT-1812. The tank capacity was 11 gallons with 1000 watts of ultrasonic power at 40 kHz, resulting in an ultrasonic power density of 91 watts/gallon. For a cycle time of ten minutes and working temperatures of 110-120° F, electrical parts such as stators and rotors were cleaned with no deterioration of the wire insulation. According to Latta Biotechnology, the long-term use of enzymes in ultrasonic cleaning tanks may be inadvisable because the natural tendency of ultrasonic energy is to degas the solution. Since enzyme cleaners work best in an oxygen-rich environment, degassing hampers the decomposition of oil and grease by the enzymes. NC3R did not conduct testing to verify this.

Manual Cleaning using Brushing and Enzymes

The performance of enzymatic manual cleaning was compared to manual parts washing using mineral spirits. In contrast to mineral spirits, enzyme cleaners are non-flammable and non-hazardous.

Automotive starter nosepieces — with fairly uniform layers of dried caked-on dirt and oil inside and out — were tested using enzymatic cleaner and mineral spirits with brushing. The mineral spirits were pumped onto the part while the part was being brushed. In similar fashion the enzymatic cleaner was pumped onto the part through the brush with a solution temperature of 105° F. To achieve comparable cleaning results the enzymatic system required two minutes of cleaning while cleaning with mineral spirits required one minute 45 seconds. The following estimates include the cost of the cleaning solution, energy, and direct labor.

	Mineral Spirits	Enzymes
Materials and Disposal	$0.12	$0.07
Energy	- negligible -	$0.07
Labor	$0.37	$0.42
Total Cost	$0.48	$0.55

A typical cost for a leased mineral spirit sink-on-drum system is $140 every 4 weeks. This price includes disposal of the spent solution and refill with fresh solution.

Cost of Equipment and Chemistry

One fifteen-gallon agitated enzyme tank including a pump and heater can be purchased for approximately $2,000-$2,500. One five-gallon pail of concentrated enzymatic cleaner costs $90 and is enough to charge the tank twice.

Advantages

- No oil skimming required
- Enzymes are non-flammable
- Equipment is inexpensive
- Enzymes are typically pH-neutral
- Spent wastes are non-hazardous

Disadvantages

- Based on NC3R testing, manual cleaning using enzymes is about 15%-25% slower than using mineral spirits
- Enzymes appear to be unsuitable for use in ultrasonic systems

Enzymatic Cleaning

Environmental Health and Safety

Enzymatic cleaners have certain environmental, health and safety advantages. The chemistry used in this study has a neutral pH, is non-solvent, non VOC (volatile organic carbon), non-toxic, non-flammable, does not exhibit any characteristics of hazardous waste, and can eliminate oil and grease in wastewater. From an EH&S standpoint, enzymes are preferable over mineral spirits and high pH aqueous cleaners.

Given the ability of enzymes to break down the oil and grease components in the cleaning bath, it may be possible for a company to discharge a spent bath directly to sewer. However, this should only be done with the approval of the local sewer authority. While the enzymes may break down grease and oil, there may be other potentially harmful contaminants in the bath such as heavy metals.

The Bottom Line

Enzymatic cleaning is being used successfully in maintenance shops and tool rooms for low-volume maintenance cleaning applications. In these cases, enzymatic cleaning replaced mineral spirit sink-on-drum systems. To NC3R's knowledge, enzymatic cleaning has not yet been used commercially in a high-volume, parts cleaning application, although this is a potentially viable option.

Where to get more information

Contact NC3R or the following vendor of enzymatic cleaning systems.

Latta Biotechnology www.cj-clean.com

Estimated Cleaning Costs for Various Parts and Equipment

Part Information				Cleaning Information				Cost ($/part)			
Part	Material	Contaminants	Level of Contam.	Process	Cycle time	Temp	Cleaning results	Chem. cost	Elect. cost	Labor cost	Total $/part
Starter nosepiece	aluminum	Dirt	High	Enzymatic tank with brush	2 min.	105° F	Patches of grease in corners on outside, large patches of grease inside	$0.07	$0.07	$0.42	$0.55
		Dried Oil	High								
Starter nosepiece	aluminum	Dirt	High	Enzymatic tank, immersion with agitation	30 min.	105° F	Heavy grease layer gone, but thin layer of grease remaining	$0.07	$0.07	$0.02	$0.15
		Dried Oil	High								
Fuel Injector, small part set (30 pieces/set)	steel	Oil	Medium	Enzymatic tank, immersion with agitation	60 min.	105° F	Occasional small patch of carbon	$0.08	$0.07	$0.02	$0.17
		Carbon	Medium								
Fuel Injector cap	aluminum casting	Oil	Low	Enzymatic tank, immersion with agitation	60 min.	105° F	Very clean	$0.06	$0.07	$0.02	$0.14
Fuel Injector rod	steel	Oil	Low	Enzymatic tank, immersion with agitation	60 min.	105° F	Very clean	$0.06	$0.07	$0.02	$0.14
		Carbon	Low								

Assumptions:

$12/hr. for labor, batch size of 30 parts or small part sets, load/unload time is two minutes per batch, two batches of parts run per day, tank pump and heater run continuously.

Enzymatic Cleaning

ABOUT NC3R:

The National Center for Remanufacturing and Resource Recovery (NC3R) at Rochester Institute of Technology provides technical assistance and applied research and development to industry and government agencies interested in remanufacturing and resource recovery techniques. We provide solutions that are both economically and environmentally sound.

NC3R has proven its ability to deliver concrete solutions for the remanufacturing industry since 1991. NC3R was formed as a collaborative effort of RIT's College of Engineering, the remanufacturing industry and several federal laboratories. Funding is provided by federal and state governments and private industry.

National Center for Remanufacturing & Resource Recovery
133 Lomb Memorial Drive
Rochester, NY 14623-5608
phone: 585.475.6091
fax: 585.475.5455
email: reman@cims.rit.edu
www.reman.rit.edu