National Center for Remanufacturing & Resource Recovery (NC3R)

Ultrasonic Cleaning

Ultrasonic Cleaning of Automotive Parts

Overview of the Technology

Engineers at NC3R, as a part of their work with NYSERDA, have conducted approximately four months of intensive research into the performance of ultrasonic cleaning. They have evaluated a variety of chemistries and procedures on 14 different part categories. The results of their research are presented here for use by the automotive remanufacturing industry.

Ultrasonic cleaning is primarily an aqueous tank system that uses ultrasonic energy to remove dirt, grease, oil, and baked-on carbon from parts. Contaminants such as paint, rust, glued-on gaskets, and heavy layers of baked-on carbon can also be removed by ultrasonic cleaning but require more aggressive chemistries. Unlike some other cleaning processes, ultrasonic cleaning will not damage intricate, lightweight, or easily damaged parts. Parts that have a tendency to tightly nest will shadow each other, reducing cleaning efficiency.

Since ultrasonic cleaning is done in a tank, it is by nature a batch process. The success of the process is very dependent on the ultrasonics, the chemistry used, part geometry, and weight of the part.

The chemical cleaner used in conjunction with the ultrasonic equipment will determine what materials can be cleaned, how fast the contaminants are removed, and the temperature of the cleaning solution.

How it Works

Ultrasonic cleaning works by producing sound waves in liquids. The waves consist of both high- and low-pressure fronts. The low-pressure fronts are small enough to cause bubbles to form. The high-pressure fronts cause the bubbles to collapse. The expanding and collapsing bubbles loosen contaminants on the part surface and the chemical cleaners either dissolve or segregate the free contaminants.

As with sound waves in air, ultrasonic sound waves can be varied by both frequency (pitch) and amplitude (power). Higher frequencies will produce smaller bubbles and lower frequencies will produce larger bubbles. Larger bubbles will typically dislodge large particles and smaller bubbles small particles. Typical industrial systems are either 25 KHz or 40 KHz, which can handle the particle sizes in the range of normal automotive cleaning. Ultrasonic cleaning systems with a much higher frequency are used in the computer industry where tiny particles need to be removed.

This fact sheet has been prepared under a grant from the New York State Energy Research and Development Authority (NYSERDA). Under this grant, RIT has identified cleaning technologies for automotive parts remanufacturers that are energy-efficient, cost-effective, and environmentally friendly.

Ultrasonic Cleaning

Advantages of Ultrasonic Cleaning:

- •Able to clean delicate parts without damage
- •Able to clean small apertures, blind holes, and crevices
- •Able to clean sensitive parts (wiring, plastics) with relatively mild chemistries
- •Does not require line-of-sight for effective cleaning

Disadvantages of Ultrasonic Cleaning:

- •It is a batch process
- •Large loads are not cleaned as quickly as small loads due to energy absorption
- •Large heavy parts can "shadow" each other or themselves resulting in poor cleaning
- •Extremely thick layers of grease, and grease mixed with dirt, are slow to remove
- •Aggressive chemistries combined with ultrasonics can pinhole foil and pit some materials

Configuration of Equipment

The most basic piece of equipment for ultrasonic cleaning is a stainless steel tank with an ultrasonic transducer and power supply (frequency generator), and is usually referred to as a benchtop unit. More advanced units may include features such as heating, filtration, mechanical agitation, rotating baskets, ultrasonic power controls, oil skimmers, water level controls, and frequency modulators to improve solution degassing. A number of companies supply ultrasonic cleaning equipment, and are listed at the end of this fact sheet.

No More Solvents!

A carburetor remanufacturer formerly used manual solvents parts washers to clean carburetors. This was a very labor-intensive operation, requiring a technician to spend between 15-20 minutes per carburetor. In many cases, the carburetor then required additional cleaning in a dip tank containing caustic soda, followed by a hot water rinse.

After installing an agitating ultrasonic parts washer, three carburetors could be cleaned in a single batch with a total cycle time of 15 minutes, and only two minutes of labor per batch was needed to load and unload parts. The manual solvents parts washers were no longer needed, and caustic soda consumption was cut in half. The increases in energy consumption and cost of cleaning chemistry were more than offset by much larger savings in labor and waste disposal costs as shown below:

Energy	+$362
Materials (includes waste disposal)	-$2,090
Labor	-$31,200
Total	-$32,928

Because the purchase price of the unit was only $15,000, the cleaning system paid for itself in only five and a half months. A five-year CD would have to earn an annual interest rate of 219% to generate comparable financial performance!

Environment, Health and Safety

The ultrasonic process is well suited to aqueous cleaners. As such, it provides an environmentally friendly alternative to mineral spirit cleaners and chlorinated hydrocarbons. Aqueous cleaners are also safer for workers by eliminating flammable solvents and the health risks associated with chlorinated hydrocarbons. Some of the more aggressive aqueous chemistries used in ultrasonic cleaning equipment are either strongly acidic or strongly basic, which have their own health risks. There are many very good neutral pH or near neutral pH chemistries that do an excellent job of cleaning greasy and dirty parts. From an environmental perspective, it is preferable to avoid chemistries that contain metal chelating agents because of the difficulty in treating the wastewater to remove the metals.

Waste Management

The type of waste generated from ultrasonic cleaning will be somewhat dependent on which chemistry is used. The chemistries which split out oil will have an oil waste stream from the oil skimmer. The process will also produce sludge, and eventually the cleaning solution must be disposed of. The chemistries used in the NC3R evaluation were relatively benign. None of the spent cleaning solutions resulting from this project demonstrated hazardous waste characteristics of toxicity, reactivity, pH, or flammability. In many cases, the aqueous chemistries evaluated in this project could be discharged to the sanitary sewer, but that would depend on the requirements of the local municipality.

Ultrasonic Cleaning

Cost of Equipment

There is a wide variety of ultrasonic cleaning equipment available to the automotive parts rebuilder. The least expensive units are simple benchtop cleaning systems about the size of a fish tank, with price ranges from $2,000 to $7,500. More elaborate cleaning systems with pumps, air spargers, oil skimmers, and agitating parts baskets are also available at a cost of $10,000 to $30,000. The more expensive systems allow for contaminant removal from the surface of the cleaning solution, thereby avoiding recontamination of the part when removing it from the tank.

How the Chemistries Perform

In general, all the chemistries tested removed oils and greases along with the attached dirt. Very heavy layers of grease were only partially removed at extended times (greater than 30 minutes). None of the chemistries evaluated removed rust. Strong alkaline chemistries can remove rust but may be hazardous to dispose of unless neutralized with acidic solutions prior to disposal.

The equipment used for this project consisted of a tabletop ultrasonic tank and an agitating ultrasonics parts washer, both manufactured by CAE Ultrasonics. The tabletop unit was a CAE GMJ-1812 15-gallon benchtop tank with 1000 watts of power at 40 kHz. The larger unit was a 110-gallon Grease Monkey GMP-3527 with 4000 watts of power at 40 kHz.

The Bottom Line

Ultrasonic cleaning systems **perform best** in cleaning parts that are not extremely dirty, are relatively intricate, and/or easily damaged by other cleaning methods. For example, a ball bearing assembly is ideally suited for ultrasonic cleaning: the part is intricate, is easily damaged, and typically does not have heavy dirt loads. Also, a bearing requires relatively high cleanliness for long life. A similar part would be a carburetor, which again is intricate, has high cleanliness standards for optimum fuel flow, and will not tolerate any dirt residue in needle valves.

Ultrasonics **do not perform well** on parts with very heavy dirt loads or very heavy grease layers because an extended cycle time is required to fully remove those contaminants.

Where to get more information:

Contact NC3R or the following vendors of ultrasonic equipment.

Blackstone-Ney Ultrasonics www.blackstone-ney.com
Crest Ultrasonics Corp. www.crest-ultrasonics.com
Branson Ultrasonics Corp. www.bransoncleaning.com

Part Information					Cleaning Information				Cost ($/part)				
Part	Component	Materials of Construction	Contaminants	Level of Contamination	Temp	Chemistry/ concentration	Cycle time	# parts per basket	Results	Energy	Labor	Materials	Total
fuel pumps, fuel injectors	camshaft	steel	thick oil	medium	150F	Brulin QR (5%) 815 GD (15%)	10 min.	20	excellent	$0.047	$0.024	$0.215	$0.287
			carbon	medium									
	gear with bearings	steel	grease	low	140F	CAE Monkey Brew (12%)	15 min.	30	excellent	$0.030	$0.016	$0.125	$0.170
			oil	low									
starter	return spring assembly	steel	dirt	low	125F	Optima GP100 (33%)	15 min.	50	good *	$0.015	$0.010	$0.112	$0.136
			grease	low									
			rust	low									
throttle body	throttle body throat	steel	grease	medium	160F	Armakleen M400 (10%)	10 min.	20	good *	$0.053	$0.024	$0.178	$0.255
		aluminum	oxidation	medium									
		brass	rust	medium									
		plastic											
		rubber											
alternator	brush holder	aluminum	dirt	low	120F	Tarksol HTF 40 (5%)	10 min.	100	good	$0.006	$0.005	$0.032	$0.043
		plastic	grease	low									
		copper	carbon	low									

Assumptions used:

2 minutes per cycle needed to load and unload parts :

Capacity of tank is 110 gallons; uses 4 generators rated at 1 KW each with 1/2 hp pump :

4 batches run on single heating; each cycle loses 15% of heat energy : Lifetime of cleaning bath is 160 cycles : Costs are $12 per hour for labor, $0.10 per KWH,

$2.00 per thousand gallons of water : Temperature of bath water prior to heating is 70 deg F : Cleaning bath is replenished 3 times with 1/2 gallon of liquid between changeovers :

Evaporative losses of water are 2.5% per cycle : Spent cleaning baths are disposed of as non-hazardous waste, $200 per 55-gallon drum

good* would have been "excellent" except that rust was not removed. None of the chemistries used would remove rust.

Ultrasonic 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

R·I·T Center for Integrated Manufacturing Studies