Tech Article

Rethink Your Cleaning Process: Modern Vapor Degreasing is a Good Option

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At most companies the emphasis is on cutting operating costs. And there is one potentially large source of savings in the parts cleaning department. Consider switching your aqueous or other cleaning system for a small, fast and efficient vapor degreaser. Today, many innovative manufacturers are doing just that, simply to save money on their electric bills. Aqueous cleaning delivers quality results, but aqueous systems tend to be large and complex. Vapor degreasers are usually smaller and simpler. That simplicity enables them to deliver a more consistent and headache-free cleaning process than many aqueous systems. In fact, a properly designed and maintained vapor degreaser can be more budget-friendly, parts-friendly and planet-friendly than an aqueous cleaning system of comparable capacity.

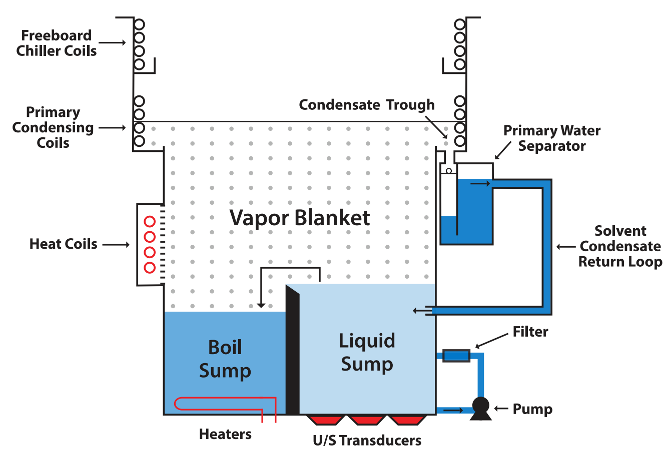
The Benefits of Low-Boiling Solvents

Many younger engineers today have never seen a vapor degreaser, so it might be worthwhile to review the technology. First, the term vapor degreasing describes a type of cleaning system based on solvents with boiling points of 90-170°F. Unlike water, these solvents also have low viscosities, low surface tension ratings, high densities, low specific heat and low latent heat. Used in properly configured equipment, they can deliver affordable, fast, reliable, safe and environmentally acceptable cleaning.

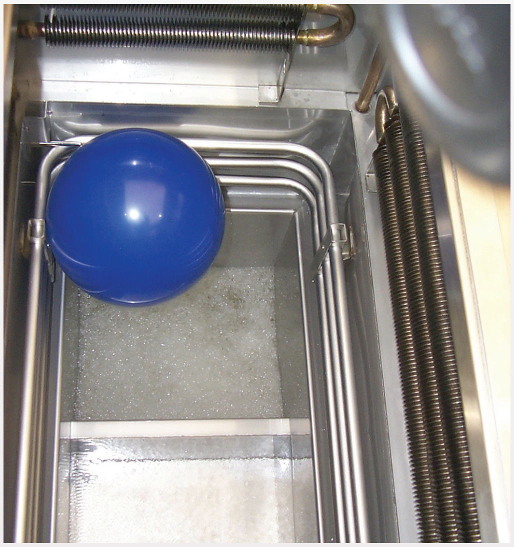
With a vapor degreaser, solvent placed in the machine's boil sump heats up using electric heating elements, hot water coils, steam coils or a heat pump unit. The boiling solvent produces a clear, dense vapor that rises into the chamber above and gradually displaces the air there. This is the vapor blanket, and it helps contain the liquid solvent inside the machine.

Eventually, the vapors rise to the first set of refrigeration coils – the primary condensing coils. The coils chill the vapors and condense the solvent back into its liquid state. This condensate drips into a trough that wraps around the internal circumference of the machine.

At this point, the distilled solvent is routed into the rinse sump. Because the rinse sump already is filled with clean solvent, the addition of more solvent causes it to overflow and spill solvent back into the boil sump. This purging maintains a constantly clean rinse sump. It also concentrates any contaminants into the boil sump for easy removal and maintenance.



The design of a vapor degreaser stems from the simplicity of low-boiling solvents. With few moving parts, such systems are smaller and cheaper than equivalent aqueous systems.



Here is the basic operating principle of a well-designed vapor degreaser. Solvent vapors lift the blue balloon off the surface of the liquid solvent. When the vapors condense back into liquid, the balloon will fall and float on the liquid surface.

The Lowdown on H2O

How does all this differ from cleaning with water? To overcome some of water's natural chemical limitations, aqueous cleaning processes need more complex systems or use additives to make it an effective cleaning agent.

One issue stems from surface tension – the measure of the wettability of a liquid. The lower a liquid's surface tension, the more easily it flows across a substrate as well as around and under the soiled parts, creating more opportunities for cleaning to occur. In general, high surface tension equates to poor cleaning. If you can't wet, you can't clean.

Surface Tension and Viscosity

Water has the highest surface tension of any popular cleaning agent, necessitating the addition of surfactants to lower the surface tension of aqueous cleaning formulations. Other additives such as detergents (alkaline formulations are common) boost the cleaning power of the water mixture, especially to help remove organic contaminants.

Even with these additives, the surface tension will still be higher than modern solvents. Indeed, surfactants and detergents can actually be considered contaminants since it is sometimes difficult for the rinse water to remove them completely.

This manifests itself in occasional "spotting" on cleaned parts. Additives and high-pressure sprays can improve system performance, but in general, a solvent with low viscosity is going to out-clean water simply because the low-viscosity material can get into and out of places that water cannot.

Density

The second problem area with water is its density. When it comes to cleaning, heavier is better. Many applications feature insoluble particulates that need removal. It takes less energy for a solvent with low surface tension and low viscosity, combined with high density to remove particulates from substrates. From there, it is simple for a properly-designed filtration system to remove the particulate from the solvent.

Heat

In either type of system, cleaning is usually enhanced if the solvent is warm. The energy required to raise the temperature of a liquid is called its specific heat. It takes a lot of energy to raise the temperature of water, but low-boiling solvents have a lower specific heat and work at lower temperatures, which reduce energy consumption.

A related issue pertains to drying the parts after cleaning. The latent heat of vaporization measures the energy required to shift a chemical from liquid to gas phase. Aqueous cleaning systems use more energy both to heat the cleaning agent above the boiling point of water and to dry water from cleaned parts, than a system that uses a solvent with a lower latent heat of vaporization, lower specific heat and lower boiling point. Modifications such as air knives are available for aqueous systems, but these increase energy consumption.

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This modern, medium-capacity vapor degreaser features an internal automatic hoist and off-set distillation to reduce its footprint.

Photo courtesy of EZG Manufacturing.

Chemical	Characteristics Affecting Solvent Efficiency Surface Tension	Viscosity,cP	Specific Gravity	Latent Heat
Acetone	25.2	0.31	0.78	123.8
CFC-113(Freon)	17.3	0.68	1.56	63.1
HCFC-141b(Genesolv)	18.2	0.45	1.25	53.3
HFC-43-10(Vertrel™)	14.1	0.67	1.58	31.0
IPA	22.10	1.06	0.81	167.7
nPB(Bromothane)	25.9	0.49	1.32	58.8
TCA(1,1,1-trichloroethane)	25.9	0.79	1.32	57.5
Water	72.80	1.00	1.00	543.0

Footprint

Cleaning systems come in a myriad of sizes, configurations and capabilities. Different soils and part geometries can dramatically affect the cleaning efficiency of a given system.

In general, most solvent cleaning processes tend to be vertical, moving parts up and down in the cleaning system. Entirely self-contained, vapor degreasers are usually single-box machines about the size of a large desk or kitchen table. For example, a typical medium-sized vapor degreaser has outer dimensions of about 60 x 30 inches, with two cleaning tanks that are 10 inches wide, 12 inches long and 10-12 inches deep.

In contrast, aqueous processes tend to be horizontal, moving the parts through a series of dip tanks. Aqueous cleaning systems typically have a 50-60% larger footprint than vapor degreasers of the same capacity, simply because of the need for more tanks, larger pumps, blowers, filters and so on.

Energy Consumption

Given that water has to work harder than solvents to accomplish the same cleaning task, it is informative to compare the energy consumption of the two types of systems. Based on the parameters outlined above, the vapor degreasing machine will typically use 3-5 kW of electricity per hour of operation. By contrast, due to the larger pumps, and added blowers and filters, the aqueous system normally uses 8-10 kW of electricity per hour of operation.

Another consideration is stand-by power draw – that is, use of electricity to keep the machine ready for operations. In order to minimize solvent losses, vapor degreaser refrigeration units should be kept operational at all times. This generally requires 0.5-1 kW/hr. of electricity. But at many companies, the heaters on aqueous cleaning systems never shut down because of the long delay in reheating the water. This means the system uses 2-5 kW of electricity, hour after hour, day after day, even when not in use.

The final tally confirms vapor degreasers to be substantially more energy efficient than aqueous cleaners. Figures are based on 20, 8-hr. work days each month and four, 48-hr. weekends each month, with an electricity cost of 10.5¢ / kWh.

A Side by Side Comparison

Here is a very useful comparison from a supplier of both aqueous and solvent cleaning equipment. The company's medium/large vapor degreaser costs around

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The vapor degreasing machine contains two chambers: the boil sump and the rinse sump.

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$50,000-$70,000. It holds 50 gal of solvent and is 90 inches long x 36 inches deep. It uses 12 kW of power at startup, about 6 kW in continuous use and about a tenth of that power during stand-by mode depending upon the solvent.

In contrast, the company's aqueous system with comparable cleaning capacity costs around $100,000. It has four sumps and has a footprint almost twice as large – 179 inches long x 34 inches deep. It uses 17 kW of electricity during startup and 12 kW during use, operating at 140°F.

Many aqueous systems enhance cleaning with ultrasonics, adding a further 200-500 kW of power consumption per tank. But whereas most vapor degreasers have only one tank fitted with ultrasonics, aqueous cleaning systems generally have three or more. So, ultrasonics add roughly another 1-2 kW of energy consumption to aqueous systems.

Don't Forget the Auxiliary Equipment

Aqueous systems are not single-box designs. Auxiliary equipment required, in addition to the basic three-to-five tank washing and rinsing system includes, a deionized (DI) water system, some type of dryer and a wastewater treatment system. Each auxiliary process has its own energy requirement.

A typical aqueous batch system has one or two wash tanks and two or three rinse tanks that require 2-5 gpm of DI water. The DI system also needs to heat the water to operating temperature as typical aqueous systems cannot tolerate large influxes of cold water. Assuming a cleaning temperature of 140°F, the deionizer will need at least 2-3 kW of power simply for purification and heating, and more for the pumps and support equipment.

At the other end of the system, parts need to be dried. Infrared heaters, blowers, turbo-blowers and air knives dry parts. On a typical aqueous cleaning system, any of these drying approaches can easily use 5 kWh. That number could double on a bigger machine simply because of the larger motors, fans and compressors required.

Wastewater Treatment

Wastewater treatment is a very complex issue because of the wide variety of processes and options available. In addition, some plants have suitable facilities already in place, so the extra energy consumption of waste treatment for a cleaning process may not be significant.

However, if the primary use of the water treatment system is to support the aqueous cleaner, then the energy costs and footprint of the waste treatment system are opportunities for savings. Assuming the system needs to process 5 gpm of wastewater, even the most frugal waste treatment system is going to use 3-5 kW of power. In general, aqueous cleaning systems always add cost and burden to plant treatment facilities.

Climate Controls

Each of these auxiliary systems also adds heat to its surrounding environment, increasing the load on plant HVAC systems. The differences here are striking; the vapor degreaser mentioned above will add about 82,000 Btu/hr. of heat to the room in which it is operating, while the aqueous system will add nearly 300,000 Btu/hr. The aqueous system will also add approximately 15 lb. (roughly 2 gal) of water into the plant air every hour, which will need to be removed by the HVAC system.

Stand-by Power Draw

One last consideration is stand-by power draw – that is, use of electricity to keep the machine ready for operations. In order to minimize solvent losses, vapor degreaser refrigeration units should be kept operational at all times. This generally requires 0.5-1 kW/hr of electricity. But at many companies, the heaters on aqueous cleaning systems never shut down. This is because of the long delay in reheating the water. This means the system uses 2-5 kW of electricity, hour after hour, day after day, even when not in use.

As shown in Table 2, the final tally confirms vapor degreasers to be substantially more energy efficient than aqueous cleaners. Figures are based on 20, 8-hr work days each month and four, 48-hr weekends each month. With an electricity cost of 10.5¢ / kWh.

Table 2: COMPARATIVE ENERGY COSTS OF SOLVENT & AQUEOUS CLEANING SYSTEMS

Task	Vapor Degreaser (kWh)	Aqueous Degreaser (kWh)
Deionize and heat water	0	1
Operate degreaser	4	8
Drying process	0	5
Wastewater treatment	0	4
Total electrical consumption/hr.	4	18
Total operating consumption/month	640	2,880
Stand-by electrical consumption/day	16	48
Stand-by consumption/month	512	1,536
Total system electrical consumption	1,152 kWh	4,416 kWh
Total operation cost	$109/month	$420/month

What Goes Around, Comes Around

Now, aqueous cleaning is undergoing scrutiny since they use such large amounts of electricity and water to clean parts. Growing environmental concerns are generating renewed interest in vapor degreasing since it uses little electricity and operates without water. In addition, a vapor degreaser is not only a parts cleaner but also a continuous recovery and recycling system. The cleaning fluid recycles and purifies for reuse in the vapor degreaser many times. It also concentrates the soil and contaminants, minimizing the amount and frequency of waste disposal.

The Need for Greener Cleaning

Vapor degreasing is a proven technology that goes back to the 1940s. It was originally used to clean automotive and aviation parts. In the 1960s, vapor degreasing evolved with the introduction of electronics and circuit boards. It gained wide-spread acceptance as the preferred method of cleaning. During that time, cleaning solvents like CFC-113, 1-1-1-trichloroethane and HCFC-141b cleaned parts. However, by the early 1980s, concern about the ozone "hole" emerged and the global effort to protect stratospheric ozone began.

With the ratification of the Montreal Protocol in 1987, most countries began a brisk phase-out of ozone-depleting solvents. Many of the most popular solvents used in vapor degreasers at the time were ozone-depleting substances. So, when most of those solvents were banned in 1997 many manufacturers looked to aqueous cleaning as a replacement.

In the early 2000s the vapor degreasers still in use switched to better replacements like n-propyl bromide (nPB), Perchloroethylene (Perc) and Trichloroethylene (TCE). However, due to their own toxicity concerns along with air groundwater quality issues, they are also being phased out for better alternatives.

Improved Cleaning Fluids
Today, ozone-depleting solvents are a distant memory. They are replaced by HFO-based (Hydrofluoroolefin) cleaning fluids. They are low odor and low toxicity. Many are also more environmentally friendly. The new cleaning fluids have a very low GWP which helps reduce greenhouse gas effects. They also have low or zero VOC content to meet strict regional air quality regulations. Plus, they are formulated to meet increasingly stringent local, national and global environmental policies. By proactively changing to a better cleaning fluid now, companies can be prepared for compliance with worker and environmental safety regulations not only today, but with those emerging in the future.

Fortunately, there are a number of vapor degreasing cleaning fluids that not only clean exceptionally but are also highly cost effective. While cleaning fluids are more expensive on a "per pound" basis than water, the two methods are roughly comparable in cost when you account for the surfactants and saponifiers used in aqueous cleaning chemistries. Unlike aqueous systems, vapor degreaser solvent consumption is measured in pounds per week instead of gallons per hour. In addition, vapor degreasers are designed to concentrate soil and contaminants, minimizing waste disposal. Aqueous systems generally dilute contaminants, making waste disposal more complex and costly. Therefore, perhaps it is time to rethink your cleaning methods and consider the environmentally friendly and headache-free vapor degreasing cleaning process.

Find a partner
Whether aqueous or solvent cleaning, either method impacts the environment. You can't avoid it by switching from one cleaning method to the other. The goal is to minimize water pollution, control emissions and limit waste disposal. Therefore, when choosing which cleaning method to use, it is recommended that you work with a precision cleaning expert that specializes in both aqueous and vapor degreaser solvent cleaning. They can help assess your particular cleaning project and recommend the fluids and process that will work best.

About the Author:
Mike Jones, retired Vice President of International Sales for MicroCare, has over 30 years of experience in the critical cleaning industry. He is a prolific writer and educator focusing on critical cleaning in general and vapor degreasing and benchtop cleaning in particular. For more information, visit www.microcare.com.