CHEMAWARE™

A COMPARISON BETWEEN SOLVENT CLEANING AND AQUEOUS CLEANING

What is better for metal cleaning – aqueous or solvent-based solutions? The truth is, both are effective cleaning methods, and the answer will depend on the specific context. Since aqueous and solvents work in a completely different way, depending on the technical cleanliness requirements, the components to be cleaned and the contaminations, one may be more effective than the other in certain situations.

In order to identify the right cleaning solution for your application, you need to understand how these two methods differ in their working. And not just that – total cost of ownership, safety, and sustainability are equally important aspects that should be considered in a well-rounded assessment.

This guide provides a basic comparison between the two in some key areas to support you in your metal cleaning decision.

WHICH CLEANING MEDIA HAS A BETTER BIODEGRADABILITY?

As a definition, biodegradable means capable of being decomposed back into elemental components by biological agents, especially bacteria. Biodegradability depends on the formulation and the ingredients.

SOLVENT CLEANING

Some modified alcohols are classified as biodegradable according to tests carried out as part of the REACH registration (Method: OECD 301 E; Evaluation: Readily biodegradable).

WATER-BASED CLEANING

Not all water-based products are biodegradable. The vast majority of water-based cleaners contain surfactants, biocides, complexing agents, dyes, fragrances etc. Several of these compounds are not biologically degradable and, depending on their concentration, may be harmful to fauna and flora in surface waters.

Since soils are often not biodegradable, the cleaner – even if biodegradable in itself – will still have to be treated and disposed properly.

WHAT IS THE WORKING MECHANISM?

Solvent and water-based cleaning work in a completely different manner. Solvents enable the chemical dissolution of oils, greases and solids in the cleaning solution while water-based detergents emulsify and encapsulate contaminants so they can be washed away.

SOLVENT CLEANING

Solvents dissolve contaminations in the cleaning solution. In other words, soils are diluted in the solvents. Metal parts are immersed in a solvent (or sprayed) that is continuously conditioned through filtration and distillation. Cleaning power can be further improved by mechanics such as the use of ultrasonic.

The parts then undergo vapor cleaning where pure solvent vapor reaches the entire surface including tiny holes, condenses on the cooler parts, thereby removing virtually any residual oil film. The cleaned parts are then removed dry following a (vacuum) drying process.

Solvents are universally compatible with different metal types and are generally suitable for a wide range of contaminants.

WATER-BASED CLEANING

Water-based cleaning relies on chemical additives and agitation. Detergents, surfactants, emulsifiers or buffers are added to the water to facilitate and enhance its cleaning performance for the removal of contaminants. The process can also be aided by heat, agitation and time.

Multiple wash stations are followed by rinsing baths to remove any residues. Parts are then dried with heaters or blowers.

Water-based cleaners are usually concentrates which are added to the water. They are often “soil specific”, which means the detergents/chemicals have to match the contaminants and the metal types to be cleaned.

WHAT IS THE ENVIRONMENTAL IMPACT?

Every cleaning system has its own environmental impact that manifests in different ways. Various factors, such as the use of chemicals, water consumption, energy usage, recycling potential and waste handling, should be taken into consideration.

SOLVENT CLEANING

Solvents have good drying behavior and they can penetrate easily into tight spaces. But such properties can also bring inherent risks such as air emissions or ground penetration. The use of modern, closed machine technology, in combination with a closed loop solvent delivery system, is therefore key to ensuring an emission-free and spill-free transport, storage and handling of solvents.

Solvent cleaning does not require heaters or blowers since parts readily come out dry from the cleaning machine due to the vacuum condition. While energy is required to keep machine operation under vacuum, this also lowers the boiling points of solvents in a vacuum, hence accelerating their evaporation and enabling quick drying of metal parts within a shorter cycle time.

Since solvents can be continuously recycled through built-in distillation in closed cleaning machine, there is less waste generated. Figures from the European Union[1] show that the most modern solvent systems with up to date solvent management practices can remove 100 kg of oil using less than 15 kg of solvent (Process optimization can bring down solvent consumption further still). In comparison, to clean off 100 kg of oil, approx. 100 kg of water-based cleaner is consumed in a water-based system.

Waste that stems from solvent cleaning typically consists of concentrated oil with some solvent residues. Depending on the components within, it can be recycled at a waste recycler, where the solvent can then be brought back into the resource loop.

WATER-BASED CLEANING

Water is often associated with "being green", however, not all aqueous cleaners are biodegradable. Water itself is also a finite resource.

The energy consumption in a water-based process can be significant, due to the energy requirement to operate high-pressure pumps; heat the cleaning water; dry the metal parts; as well as treat and purify used water for re-use or disposal.

Its typical horizontal set-up also demands more space and hence more electricity to run.

As a relatively slow-drying cleaner, water requires 10 times more of the latent heat of vaporization (2259 J/g) than that of solvents (200-300 J/g).

Waste stream will consist of oils as well as contaminated water which have to be treated properly:

- Oil residues (to be disposed as waste oil similarly to most solvent cleaning processes)
- Waste water often needs to be treated on site (depending on the types of contaminations and cleaner used, in accordance with local legislation), prior to disposal at municipal sewage plant. The waste water can, however, be recycled if appropriate facilities are available on-site to purify the used water.

[1] Chemical product services in the European Union, European Commission, January 2006

WHAT IS THE COST OF OWNERSHIP?

The true cost of ownership depends on both the acquisition costs – machine, installation and retrofits – as well as the operating costs, including chemicals, utility bills, process control and bath maintenance, floor space, waste disposal charges, not to forget labor costs for operation and process monitoring.

SOLVENT CLEANING

- Often higher capital expenditure for standard solvent machine technology and initial first fill chemicals.
- Zero water consumption.
- Lower energy consumption with no need for additional heat during vacuum drying normally.
- Very low solvent replacement volumes, and many fewer solvent bath exchanges, due to continuous solvent recycling via in-built distillation.
- Low process control & bath maintenance costs. No additional chemicals (beside stabilizers when necessary) are required, so the chemistry in the vapor degreaser remains consistent and requires little attention to ensure a constant cleaning performance. Much of the process can be automated using programmable process controls in machine technology.

WATER-BASED CLEANING

- Often lower capital expenditure for equipment set-up and cleaning agents (To enhance cleaning performance and machine efficiency, the addition of ultrasonics, evaporators for water, treatment plants for wastes etc can increase initial investment accordingly).
- Buying and pre-treatment of water, plus disposal of wastewater.
- Higher energy consumption to increase temperature level for optimal cleaning, in addition to extra energy for drying cleaned parts.
- More frequent replenishment of aqueous cleaners as they get consumed in the process.
- High process control & bath maintenance costs due to the need to constantly monitor and adjust the concentration of the chemicals (e.g. builder and surfactants) to secure a stable process. Potential bioburden issues add another layer of process control and necessitate the use of biocides.

WHAT ARE THE ADVANTAGES OF EACH TECHNOLOGY?

Both solvent and aqueous cleaning have their distinct advantages. The choice of the suitable cleaning agent will depend on the required technical cleanliness, the types, geometry and volumes of metal to be cleaned, the kinds of contaminations, and desired throughput requirements among others.

SOLVENT CLEANING

- First choice for non-polar contaminants, like oils and greases
- Lower chemical consumption (efficient recycling of solvent within the distillation unit in closed cleaning machine) and therefore lower lifecycle costs
- Better cleaning results for complex or tiny parts
- Lower energy usage
- Lower labor costs due to easier process control and bath monitoring
- Less floor space requirement
- Better drying behaviour
- Many fewer bath exchanges
- No water consumption
- Universal compatibility with metals
- Mostly one pure substance (no additions of chemicals such as surfactants, builders required), simplifying media monitoring efforts

WATER-BASED CLEANING

- First choice for polar contaminations, like salt residues
- Can be more efficient when working wet in wet (E.g. water-based painting, galvanization)
- Less storage and transport requirements for chemicals since concentrates are used
- (Depending on the pH-values) no effect on rubbers, plastics, or painted surfaces
- Cleaning can be combined with surface finishes (phosphating, chromating etc.) or deposition of protective coatings
- In-line processes possible
- Vast majority non-flammable*
- Free of volatile organic compounds (VOC)
- Due to different formulations, potential to adapt to the cleaning requirements

* Non-flammable solvents such as Perchloroethylene also exist.

WHAT IS THE DIFFERENCE IN CLASSIFICATION?

The classification depends on the chemical makeup and is therefore impossible to generalize. Both solvents, as well as water-based cleaning, can be classified as hazardous substances which will then require special handling, recycling and disposal procedures.

SOLVENT CLEANING

Each solvent has its individual classification.

An example of modified alcohol:

Label elements
Labelling according to Regulation (EC) No 1272/2008 (CLP Regulation)

Hazard statement(s)

H315	Causes skin irritation
H319	Causes serious eye irritation

WATER-BASED CLEANING

Since a variety of chemicals are added in a water-based system to extend the application range and improve cleaning efficiency, the classification will depend on the actual chemicals.

An example of a neutral water-based cleaner:

Label elements
Labelling according to Regulation (EC) No 1272/2008 (CLP Regulation)

Hazard statement(s)

H315	Causes skin irritation
H318	Causes serious eye damage

HOW DOES THE MEDIA MONITORING COMPARE?

The efforts, time and complexity involved in ensuring process stability can differ to a great extent.

SOLVENT CLEANING

Apart from the use of stabilizers (if necessary), there are no additions of chemicals required in the cleaning process. The chemistry in the solvent vapor degreaser therefore remains consistent and requires little attention.

Generally, solvent bath monitoring should be conducted once a week which takes around 20 minutes or less.

WATER-BASED CLEANING

When using water, chemicals are added to make the cleaning of non-polar contaminations possible. The concentration of these chemicals (builder and surfactants) need to be consistently monitored and adjusted in order to secure a stable process.

With aqueous cleaning, depending on the complexity of the process, in many cases more than one or even multiple tests will be required every week.

HOW OFTEN WOULD I HAVE TO DO BATH EXCHANGE?

Since bath exchange involves costs, time and efforts, it is an important aspect to be considered in the evaluation of cleaning media.

SOLVENT CLEANING

Since solvent is continuously distilled and purified in the closed cleaning machine, it can be reused over multiple cleaning cycles which significantly reduces the need for frequent bath exchanges. Of course, as more work demand is made on less solvent input, stabilizers when necessary could be added to extend solvent lifespan.

Solvent lifespan will also depend on factors such as contaminations (type and amount of oils, fats, waxes, metal treatment fluids etc.), the type of solvent used, amount of water (humidity, emulsions) and the process parameters (time, temperature etc).

In best case scenarios, the solvent can be used for hundred thousand of cleaning cycles.

WATER-BASED CLEANING

As contaminants and oils are encapsulated, washed off and rinsed in water, unless there is proper facility to treat the used water, it will have to be disposed of on a regular basis.

Since water cleaning systems are very often not hermetically sealed systems, the evaporation losses must be monitored, measured and compensated on a regular basis.

High-quality cleaning is only of value when you can rely on the results. Choosing not just any, but the right cleaning technology that fulfills your cleaning, economic, and safety & environmental requirements is therefore a critical step. We would be happy to advise you on the right cleaning solution that brings value to your production process.

PLEASE CONTACT:

Whether you are re-assessing your current cleaning set-up, evaluating new investments, or are struggling with cleaning challenges, talk to us. We would be happy to offer you a free consultation.

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