Why solvent cleaning?

Critical differences between water and organic solvents:

Water:
- High surface tension
- 72.8 dynes/cm

Problem – Surface Tension of Water

Surface tension/surface energy

Apart from inherent laminar flow variation within a tube or pipe, high surface tension can present restrictive forces.

Kinetic energy is reduced

The high surface tension associated with water means that wettability is reduced.
"Creep" characteristics do not match that of solvents.

Effective cleaning requires liquid flow with positive surface contact in order to dissolve contamination and remove particulates by flushing.

Low surface tension of solvents (typically 25-30 dynes/cm compared with 72 for water) means that liquid can enter (and exit) complex geometric component features such as fine threads and blind holes thereby flushing out contamination. In additional a process carried out under vacuum means that restrictive air pressure elements are eliminated.

Solvent and aqueous cleaning – a comparison

Glenn Greenlees of Standard Industrial Cleaning Systems and Geiss UK examines some of the evidence

Many people believe that water based cleaning is somehow more "environmentally friendly" or "greener" than solvent formats. Such views are often based upon mis-information and are invariably held by those who have not taken the time to study the detail.

Aqueous processes can meet a wide variety of applications but the inherent physical problems associated with water very often prevent cleaning and drying efficiency to be maximised.

The restrictions of water based operations can be itemised as follows;

Surface Tension

The surface tension of water reduces with increase in temperature – at 100 degrees Celsius, however, it is still over twice the value of solvents.
Cleaning sustainability

Depending upon the level of cleanliness required water based cleaning will be a multi stage process. Initial cleaning will always be made with “dirty” water with subsequent rinsing made with progressively cleaner liquid. Note that “tap water” may appear to be clean but, as far as critical surface cleaning is concerned, contaminants such as organic matter, mineral content and colloids are present which leave staining on the surface.

Accordingly the ultimate result will be based upon the quality of the final rinse which will invariably be made with de-mineralised water to a given required quality measured in microsiemens. This “pure” water must be monitored (usually measured by conductivity or resistivity) and maintained according to specification requirements.

Cross contamination of wash and rinse waters cannot be completely eliminated and so aqueous processes produce significant amount of contaminated waste which must be disposed of correctly and compliantly. Of course clean water is environmentally friendly but waste stream contaminated with oils and particulates is not. Restrictions on waste disposal are increasingly severe.

By contrast cleaning with solvent will include a final vapour phase rinse which is always perfectly clean solvent.

Water will require a chemical additive to increase solvency - this is very often an alkaline based product with surfactants. Note that this chemical will be consumed and concentration must be monitored and maintained.

Solvent based processes use standard distillation to continuously purify the liquid which maintains cleaning performance. By-pass distillation is also used to concentrate waste up to 95%. Whilst water based processes require constant monitoring (some sceptics claim that an on-site chemist is required for high integrity applications). The continuous distillation associated with solvent cleaning affords a very robust and reliable ongoing process.

Drying/vapour pressure

Water is none volatile and drying remains a critical issue especially with complex component geometries such as fine threads, blind holes and pipe/tube applications. Considerable energy is utilised in drying. Note that with organic solvents drying is quick and efficient.

![Dampfdruckkurve fur Wasser](Vapour Pressure Curve for Water)
Compare these two graphs.

Note that the slope of the graph from the modified alcohol RG 63 is much higher from the beginning compared to the curve of water. This is due to the vapourising enthalpy of the liquids.

These two diagrams demonstrate the different boiling points of the liquids at a specific temperature. This means that water boils at 100 degrees under normal (ambient) pressure. It is also shown that the vapour pressure of water is close to 0 below 40 degrees Celsius. This means that the boiling point is very low but the concentration in the vapour phase is also very low.

This can result in drying problems.

The saturation curve of a liquid is proportional to the steam pressure - The Ideal Gas Law.

The volatility of organic solvents ensures that thorough drying of metal component parts is both rapid and thorough. Compare the latent heat of evaporation of water at 2280kJ/kg with organic solvents at approximately 200 – 300kJ/kg. By applying a vacuum to the process chamber and therefore reducing the boiling point, residual component heat will ensure instant vapourisation allowing up to 10 cleaning cycles per hour.

Cycle times
With multi step aqueous cleaning plus extended drying requirements cycle time is usually circa. 40 minutes for non complex components.

Running costs
Water based processes will generally cost three times that of solvent cleaning. This largely due to the energy costs (drying), consumable costs (chemicals and pure water provision) and waste disposal.

Environmental considerations
Note that aqueous processes require substantially more energy – this increases the operation’s carbon footprint. The Climate Change Levy must also be considered.
Health & Safety

It is important to understand that, whilst clean water if perfectly safe, most contaminants are not and the resulting waste stream may well be classed as hazardous.

Note that a solvent system offers a fully closed loop capability with both fresh solvent and waste stream management being managed by a secure delivery, storage and removal system without any operator contact.

Many believe that water based processes are somehow “greener” than solvent operations. In fact the reverse is absolutely true. It is also interesting to note that our consumables partner, Richard Geiss GmbH, is a solvent recycler. Used solvent is returned for processing and return to the market - truly an environmentally friendly package.

The choice

Many applications can be met with either water or solvent based processes, Firbimatic Spa offers both technologies. Certainly the solvent route is absolutely proven in pipe and tube cleaning. With laboratory/test facilities for both processes we are able to offer initial trials to evaluate the feasibility of an aqueous process.

About the author

The author of this article, Glenn Greenlees, is the marketing director of Standard Industrial Cleaning Systems and Geiss UK, independent distributors “dedicated to offering the world’s best in both aqueous and solvent cleaning technologies.”

Glenn believes that with the many changes in environmental legislation, solvent classification together with a strong drive towards Health & Safety improvements it is vital that potential investors are given the facts regarding the technologies available along with the relevant legalities.

Standard Industrial Cleaning Systems is the UK importer and distributor for two of the world’s most successful manufacturers Firbimatic Spa of Italy and Richard Geiss GmbH of Germany.