SOLVENTS ARE UNSUSTAINABLE?

Not when you consider these 4 environmental aspects

INTRODUCTION

The excellent cleaning quality of solvents is undisputed. However, increasing public concerns in the late 80s about chlorofluorocarbons (CFCs), which were found to contribute to ozone depletion and ozone holes, or chlorinated hydrocarbons causing ground water contamination, had caused many companies to shift away from solvent cleaning to other cleaning methods, most noticeably aqueous-based cleaning.

Some three decades later, the word solvent still conjures up negative associations for many, especially when it comes to aspects such as safety, environmental impact and in particular – sustainability.

A closer look into a wide range of technical, economic and ecological factors will reveal that such perceptions are in fact unsubstantiated. Nowadays, solvents meet strictest environmental standards and Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) requirements. At the same time, great technological advances in solvent cleaning systems are leading to environmentally sound and responsible cleaning options.

To evaluate solvent use through the lens of sustainability, the performance of the solvent itself is just as crucial as the process and system within which it is used. Taking into account energy usage, solvent recyclability, waste treatment and disposal, as well as chemical impact on the environment, solvents when used in combination with modern closed cleaning machines, may even have a better environmental profile than many other cleaning methods.

This short guide presents four important aspects that demonstrate the sustainability of solvents in metal cleaning applications.

1 VIRTUALLY NO AIR EMISSIONS WHEN USED IN MODERN SEALED PLANTS

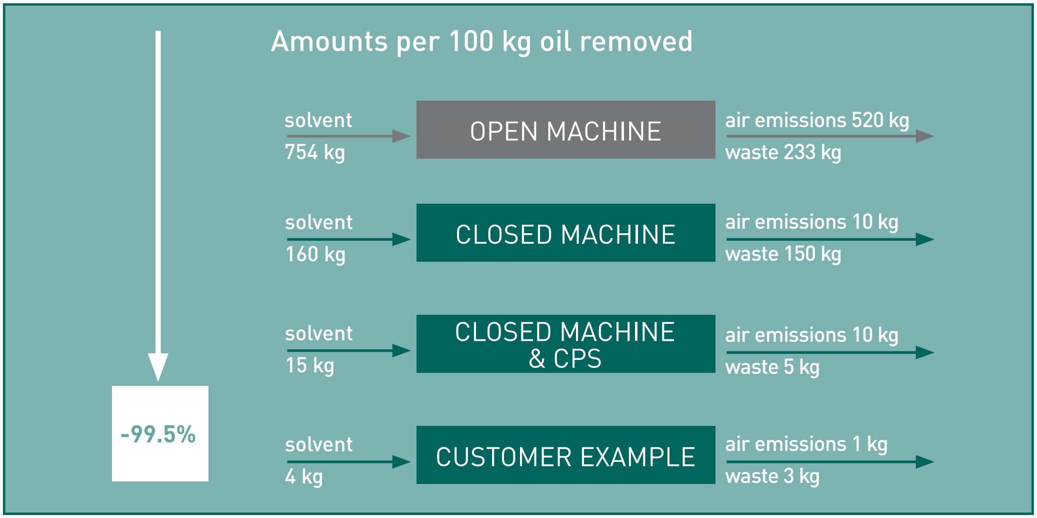
Solvent losses into the air from open top machines used to represent a major portion of organic pollution. However, modern closed cleaning machines running in vacuum conditions[1] – for both chlorinated and non-halogenated solvents – means that there is virtually no emission in the cleaning process.

In addition, the application can be fully bundled with closed loop solvent delivery systems which can prevent emission during transfer and handling of solvents from and into the machine.

Note[1]: Vacuum condition is compulsory for flammable solvents. For halogenated solvents, vacuum condition can be an option, but not mandatory.

A European Commission Report from as early as 2006 already confirmed the environmental benefits enabled by Chemical Product Services (CPS), which include the likes of stabilizers, test kits, solvent monitoring logbooks, solvent analyses etc., in solvent application.

The figure below shows the amount of solvent required to remove 100kg of oil, and the corresponding losses due to air emissions and solvent in waste streams, when different machine technology is applied.



The deployment of a closed cleaning machine can already dramatically reduce the amount of solvent used by almost 5 times, from 754kg to 160kg. With the support of CPS, such as consistent solvent monitoring and stabilization, along with the SAFE-TAINER™ System for the safe transport, handling and storage of both fresh and used solvents, the amount of solvent required can be further reduced by over 90%, dropping from 160kg to a mere 15kg.

Real-life cases show that with process optimization, the efficiency of solvent can be boosted even higher, where only 4kg of solvent is required to remove 100kg of oil – a reduction of 99.5% compared to the original 754kg required in an open-top machine. Both emissions and wastage volumes also drop significantly, while user safety standard and environmental protection are heightened at the same time.

2 MINISCULE SOLVENT CONSUMPTION AND LONG BATH LIFE

In modern, closed cleaning machine, used solvent can be constantly re-purified and nearly completely recycled in the distillation unit. This routine recycling means there is very low solvent replacement volumes necessary. It also reduces health and safety risk, and brings in cost savings not only in terms of solvent consumption, but also time, labor and paperwork due to minimal wastage. Not to mention reputation wins and the enhanced environmental profile of the business.

Nevertheless, since more work demand is made on less solvent input, the stress on solvents could increase. Regular monitoring and maintenance of the solvents can therefore help extend solvent lifespan, and in return, the bath life cycle.

Easy-to-use solvent test kits are available nowadays to enable regular, on-site solvent monitoring. Testing does not normally take more than 20 minutes a week and is usually much less complex than monitoring of water-based cleaning systems. In addition, the use of stabilizer concentrates not only helps counteract the evolving acidity, it can also prevent discoloration or metal catalytic effects while enabling safe pH value and reliable processes.

3 LOW WASTE VOLUME

Since solvents can be effectively recycled and reused following distillation, the waste volumes are much lower. Compared to aqueous cleaning, solvents can be easily separated from oils by distillation. The higher the temperature difference between solvent and oils in their boiling points, the better the separation by distillation.

The higher the temperature difference between the boiling point of the cleaning agent, and the boiling point of the oil, the better both products can be separated.

Perchloroethylene	Modified alcohols	Hydrocarbons	Oils
121 °C	170 - 175 °C	180 - 210 °C	> 250 °C

Annual waste generated based on 10,000 kg of oil entering the cleaning machine per year

Cleaner	Oil content in waste stream %	Cleaner residue in waste stream % (per 10,000 kg oil p.a.)	Annual Waste (Oil cleaned off plus cleaner residue in waste stream) (per 10,000 kg oil p.a.)	Used water
Chlorinated solvents	Approx. 95-99%	Approx. 1-5% → 100-500 kg	Approx. 10,100-10,500 kg	0 kg
Hydrocarbons	Approx. 80%	Approx. 20% → 2,500 kg	Approx. 12,500 kg	0 kg
Water-based cleaning (with 1-5% cleaning concentrate)	50% (On average 1kg of water-based cleaner is required to clean off 1kg of oil)	100% → 10,000 kg	10,000 kg (oil)	10,000 kg*

*The water consumed, which is now contaminated with oil, will be disposed entirely as waste water, unless it can be recycled in appropriate facilities in the factory.

With chlorinated solvents such as Perchloroethylene, as little as 1% (or even lower) of solvent residue can be found in the waste stream. Based on 10,000 kg of oil which may enter the cleaning machine per year that needs to be cleaned off, this would result in just about 100 kg of solvent residue in the waste stream, and therefore an approximate total of 10,100 kg of waste per year.

In a water-based system, to clean off 1 kg of oil, on average 1 kg of water-based cleaner is consumed. Hence, to clean off 10,000 kg of oil, 10,000 kg of water-based cleaner is required. Unless there is corresponding facility in the factory to treat the used water (now contaminated with oil), the 10,000 kg of water will be disposed as waste water, in addition to the 10,000 kg of oil. The different waste streams generated in aqueous cleaning such as oil, waste water, residues will need to be handled properly and with care.

If there is a significant amount of oil that needs to be removed in the cleaning process, the good distillation behavior of solvents can be a great advantage which can ensure minimal wastage and reduced carbon footprint.

4 LOW ENERGY USAGE

Thanks to their low surface tension and viscosity, solvents dry quickly and completely, leaving no moisture or residue on parts after they exit the vapor degreaser. In comparison, energy required to dry metal parts after aqueous cleaning can be 10 times higher.

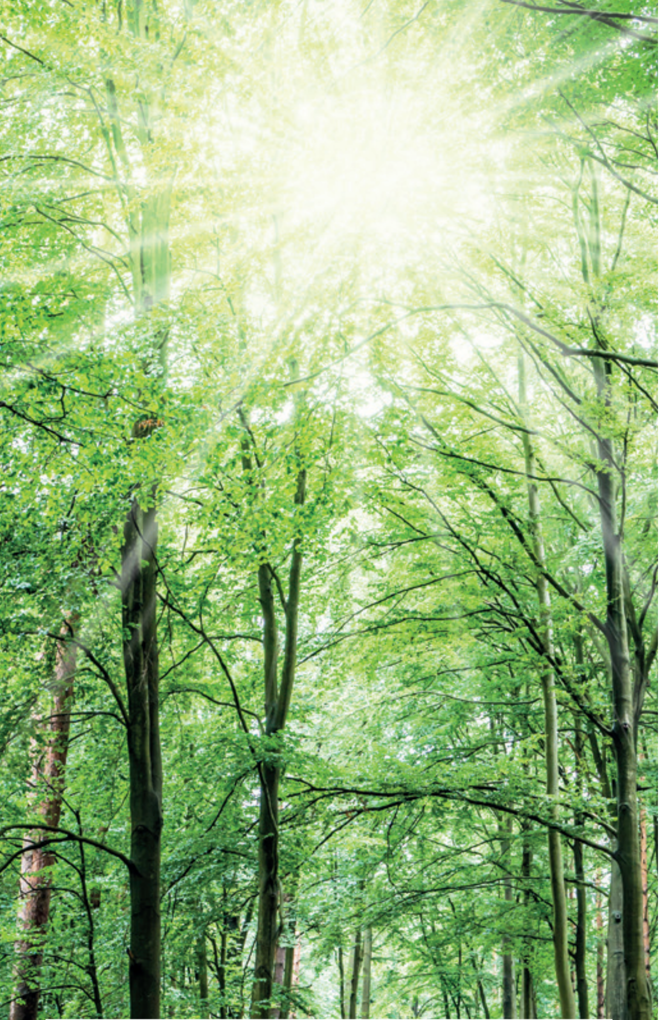
During the distillation process, solvents also require much less energy to heat to boiling temperature because of their lower specific heat capacity. It also requires less energy for it to evaporate, as illustrated in the table below.

Compared to methods such as aqueous system, solvent cleaning typically takes up little space and has in most cases a smaller carbon footprint due to reduced need for electricity and consumption of energy.

Total energy required for conversion of a liquid substance to gas (per J/g)

		DOWPER™* MC	DOWCLENE™* 1601	Hydrocarbons	Water
Specific heat[2]	J/g	0.9	2.6	2	4.18
Temperature difference (between 20 °C room temperature and respective boiling point)	°C	101	80†	80†	80
Total specific heat required to reach boiling temperature	J/g	90.9	208	160	334.4
Vaporization heat[3]	J/g	209	280	275	2,260
TOTAL ENERGY	J/g	300	488	435	2,594

Note[2]: Specific heat: Amount of heat required for a single unit of mass to be raised by 1 degree of temperature
Note[3]: Vaporization heat: Amount of energy needed to change a liquid to a vapor at constant temperature and pressure
† Under vacuum condition



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CONCLUSION

Solvents offer a perfect combination of properties: high cleaning quality, recyclability, low waste volumes, low surface tension, and non-flammability (in the case of chlorinated solvents).

Of course, every cleaning process comes with its unique requirements and challenges. By no means can solvent be a one-size-fits-all solution for all cleaning processes. But where it achieves the required degree of cleanliness, and when used in combination with a properly designed and maintained closed cleaning machine, solvent is not only sustainable, but can also offer other significant advantages including a highly effective and repeatable cleaning process, low solvent maintenance requirements and an overall lower-cost option in many cases.

SAFECHEM EUROPE GMBH
Tersteegenstr. 25
40474 Duesseldorf
Germany
Phone: +49 211 4389-300
service@safechem.com
www.safechem.com

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