Selecting An Optimum Cleaning Process

by Martina Stieglmeier, Sandra Pilz, Zestron

When searching for the optimal cleaning process, users must ask themselves numerous questions, as there is no one-size-fits-all solution. In fact, elements such as the cleaning medium and the cleaning machine must be adapted to the specific requirements. The required surface cleanliness is, for example, much higher for assembly cleaning than for stencil cleaning, which results in more stringent requirements on the cleaning chemicals and machine. As the market offers a wide range of different cleaning systems, an independent expert with a representative selection of cleaning machines, cleaning media and analytical methods at their disposal can carry out cleaning trials for the customer to facilitate the user in making the right investment decision.

Many users attempt to remove troublesome flux, solder paste or SMT adhesive residues with various manual cleaning agents before switching to an automated cleaning process. The acquisition of such a cleaning process is usually considered when the throughput becomes too large, when the cleaning is too time consuming and when the results are unsatisfactory. Once the decision has been made to purchase a new cleaning process, budgets are approved and brochures of cleaning machines and media are ordered and compared. But how do you make the right choice, and how do you get the best return on investment?

At this point, users should take a step back and answer three elementary questions:
1. What do I want to clean and how clean does it have to be?
2. What contamination do I want to remove and what cleaning agent do I require?
3. How are my throughput requirements?

What are my requirements on surface cleanliness?

This is the first important question that users should ask themselves, as it forms the basis for the decision on the cleaning agent, the cleaning machine and the cleaning process. Clearly, the demands for cleanliness are lower for stencils than for assemblies, and it is also clear that substrates have to be clean, but "*how clean?*" often remains undefined.

To get an indication of required surface cleanliness, users should examine the subsequent process steps. Should the assembly be subject to a bonding or coating process, for example, a high degree of surface cleanliness is required.

If flux or resin residues are not removed completely, they may result in field failures, such as delamination of the conformal coating, electrochemical migration, poor bonding, leakage currents etc. The more these assemblies are dedicated to critical control elements, which are often exposed to extreme environmental conditions such as frequent temperature changes, high air humidity levels or corrosive gas atmospheres, the higher the risk of failure.

Users may find guidance in the different industrial standards such as IPC or J-STD. These specify minimum cleanliness standards and suggest test methods for inspection. However, the challenge for the user is oftentimes the large number of different standards. Most frequently engineers do not have the time to compare all standards and test methods.

Eventually, therefore it is recommended to consult an expert who has detailed knowledge of all relevant standards and cleanliness requirements. This expert should have access to all test methods

Figure 1 – Surface analysis laboratory

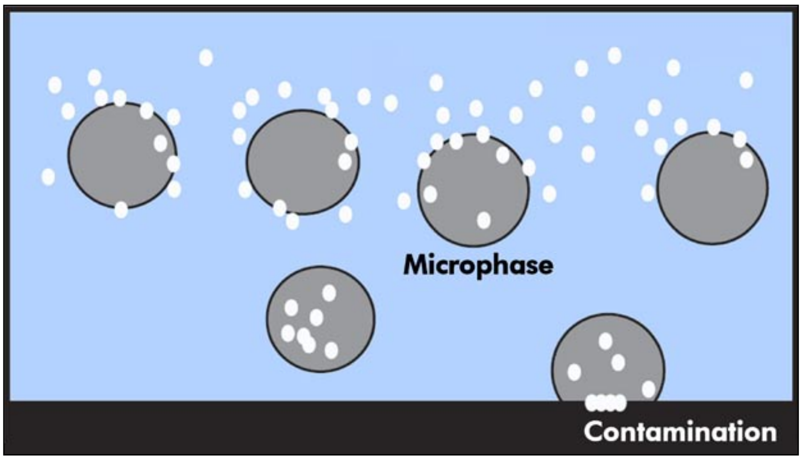

Figure 2 – Working principle of MPC Technology

available to be able to confirm the achieved cleanliness level (Figure 1). Required cleanliness qualification standards and cleanliness levels are always customer specific and can be defined by a permanent dialogue between customer and expert.

Which contamination do I encounter and which cleaning agent do I require?

This question is frequently ignored. Usually, users only focus on the selection of the cleaning machine. Nevertheless, it is of fundamental significance. One example from everyday life may illustrate the importance of selecting the right cleaning medium for the specific contamination. Stains from clothing could be removed with soap, but it would never be as clean as it could be if a special stain remover was used.

Similarly, cleaning agents should be adapted to the respective contamination (flux, solder paste, SMT adhesives). Otherwise the achieved cleaning results will be insufficient, no matter how sophisticated and expensive the cleaning machine is.

Therefore, it is important to determine the optimum chemical first. Generally, there are three different types of cleaning agent:

- Solvent-based cleaning agents
- Surfactant-based cleaning agents
- MPC cleaning agents.

Modern solvents are characterised by a wide process window with regard to the removal of all types of contamination. Thus, in some cases, they are the best option from a technical point of view. At the same time, they also have disadvantages, such as low flashpoints as well as a strong odour.

Traditional surfactant-based cleaning agents, in contrast, are aqueous and therefore not flammable. However, they have a narrow process window and tend to deplete quickly. This leads to frequent replenishments and shorter bath lifetimes, resulting in high consumption and disposal costs. Traditional surfactants also cling to the surface if not sufficiently rinsed, creating a film, which may have an adverse effect in subsequent coating and bonding processes.

MPC Technology combines all benefits of solvent and surfactant-based cleaning agents without their disadvantages. The cleaning agents are water-based and therefore do not have any flash point. Due to their wide process window, they can be used to remove a large variety of contaminants, like solvents. As the VOC (Volatile Organic Compound) content of MPC cleaning agents is very low due to minimum consumption, they have the best CO_2 balance compared to solvents and surfactant based cleaning agents. They also have very little odour.

As MPC cleaning agents do not contain surfactants, they can be rinsed off without leaving any residues. Due to their special formulation, they guarantee extremely long bath lifetimes. The active cleaning components (microphases) do not permanently bind to the contaminants, but remove them from the board surface and release them into the surrounding phase (Figure 2). Therefore the contaminants can be removed from the cleaning bath by filtration, while the active ingredients remain in the cleaning bath.

Generally, there is no predefined answer to the question "Which cleaning agent can I use to remove the contamination?" However, the various cleaning systems do have

Table 1 – Comparison of different cleaning machines

CLEANING MEDIUM	BENEFITS	DRAWBACKS
Organic solvents	+ Can remove a wide range of different residues	- High VOC content (volatile organic compound) - Flammable - Explosion-protected machines are necessary
Traditional surfactant (aqueous-alkaline) cleaning agents	+ Little to no VOC content + Non-flammable	- Short bath lifetimes - Large amounts of cleaning agent must be disposed - Residue-free drying is difficult - possible problems with coating /bonding adhesion
Water-based Microphase (MPC) cleaning agents	+ Can remove a wide range of residues + Long bath lifetimes + Residue-free drying + Cost-effective processes + Non-flammable + Little to no VOC content	- Agitation of the cleaning agent must be adapted to the process

Process type	Throughput in Euro boards per 8h	Space requirement in sq.m.
Manual cleaning	~ 50	~ 0,5
Bench top machines	~ 200	~ 0.5
One-chamber spray-in-air cleaning	~ 500	~ 3
One-chamber vacuum cleaning	~ 1000	~ 8
Dip tank process	~ 1500	~ 10
Inline cleaning	~ 3000	~ 20

Table 2 – Throughput and space requirements of cleaning machines

certain benefits and drawbacks, which should be taken into consideration before making a selection (Table 1).

Once again, the advice of an expert can be useful. To determine the best cleaning agent in relation to the type of contamination and customer specific requirements, testing the various cleaning media in production cleaning machines is recommended.

Which cleaning machine do I need?

In order to find the most suitable cleaning machine, the user has to answer the following questions, depending on the budget and preference regarding the cleaning mechanism or machine type:

- How many parts do I need to clean daily?
- How large can my machine be?

Throughput is generally measured in terms of units per hour or per shift, etc. Beyond throughput, users also have to ask themselves how the cleaning process is to be carried out by the operator.

Various semi-automatic processes are available, in which the products to be cleaned have to be manually transferred, i.e. from the cleaning to the rinsing unit. Such semi-automatic processes may feature a similar throughput as a fully automated machine, but the personnel handling cost is higher. Fully automatic processes require the operator only to place the substrates into the machine and the cleaning process is completed automatically.

Apart from the throughput, the available space in the production area must also be considered. Maybe the user places high demands on the throughput and also has the necessary funds to purchase a suitable machine, but the desired cleaning machine may not fit into the available space in the production area.

Table 2 provides an overview of typical throughput and space requirements of various types of machines. The table clearly indicates that the various machine types have vast differences in terms of throughput and space requirement. Nevertheless it can generally be said that machines with a higher throughput typically also require more space.

Figure 3 – Cleaning machines in Zestron's Technical Center

The market basically offers a multitude of variants to choose from:

- Dip tank process with ultrasonic or spray-under-immersion
- One-chamber spray-in-air dishwasher system
- Inline spray-in-air machines for fully automatic cleaning
- One-chamber vacuum cleaning machines with vapour rinsing.

In dip tank processes, the components to be cleaned are directly immersed in the cleaning agent. The contamination is removed by means of ultrasonic treatment or spray-under-immersion. The use of aqueous or solvent-based cleaning agents is possible. Besides large dip tank processes, bench top machines are mainly used for small throughputs.

In spray-in-air processes (from one-chamber to inline machines), the cleaning agent is sprayed onto the parts by means of nozzles. Spray-in-air processes are mainly water-based. Otherwise, if solvent-based cleaning agents are used, the cleaning machine must be explosion-proofed.

One-chamber vacuum cleaning however, works solely with solvents. The cleaning agent is sprayed onto the parts similar to the spray-in-air process while drying takes place in a vacuum environment, which substantially reduces the process time.

Finally, the decision on a cleaning machine must not be made on the basis of data sheets only. The user should gain a comprehensive overview on the diversity of machines types available before making any choice (Figure 3). Here again, the advice of an independent expert can help.