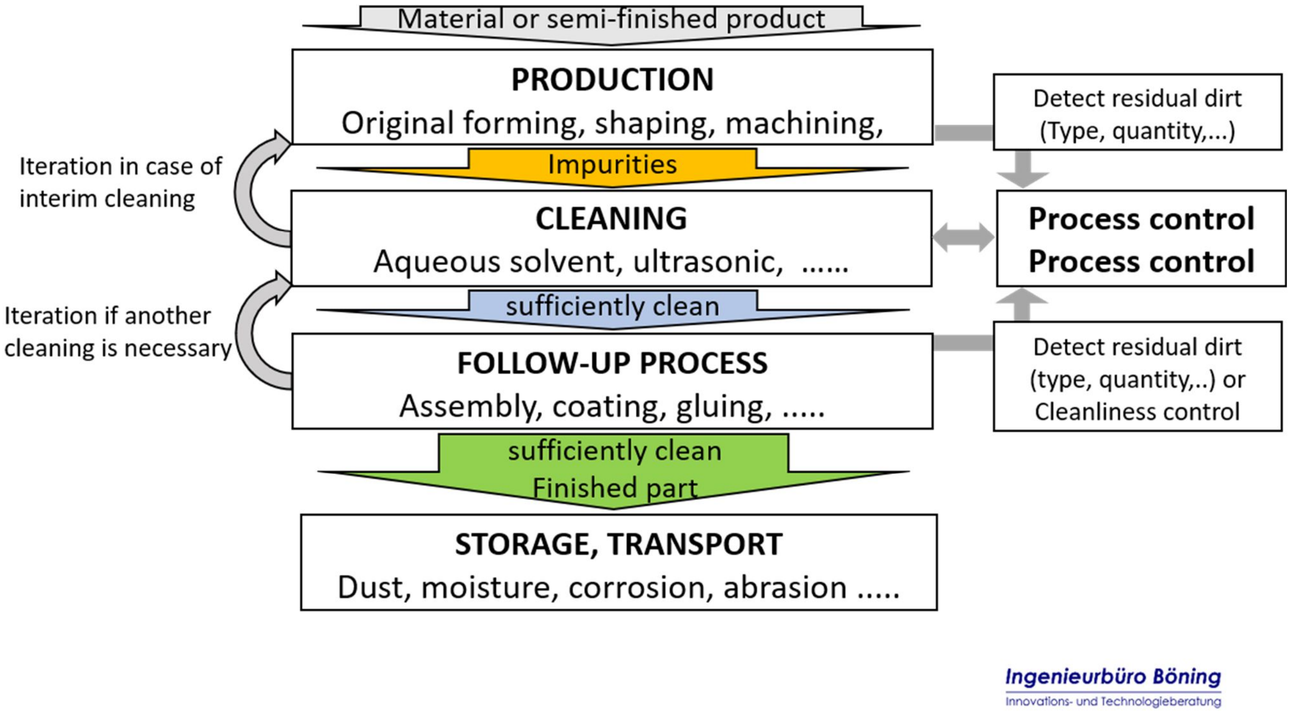
Industrial cleaning technology - part of the value chain

Why is technical cleanliness more than ever in the focus of almost all industrial sectors? The entire production landscape is undergoing a massive process of change, triggered by new manufacturing processes (e.g. additive shaping), increasing digitalization and change processes. A good example is the transformation process from an automotive industry to a mobility industry. New drives, new sensor systems and new energy storage concepts also require a higher degree of technical cleanliness in the entire process chain for their functional reliability.

According to DIN 8580, cleaning is a **manufacturing process** and, like other manufacturing processes, must be directly related to keywords such as **quality improvement, cost savings and resource efficiency.** The classical manufacturing processes are usually recorded and documented in detail. Quality problems are often caused by the insufficient attention paid to component cleanliness. With proper and well thought-out use of cleaning, costs can be saved! The optimization of cleaning lines does not necessarily mean that the entire existing plant technology has to be replaced by new equipment. Nevertheless, many companies cite this as the first point. **The investment in new processes and plants certainly often leads to positive results, but is usually not necessary at all or only to a lesser extent!**

It is noteworthy that the second most frequent measure mentioned is employee training. It is advantageous if decision makers for the equipment of the cleaning system have been trained beforehand at least about cleaning technology basics. **However, it is of central importance that not only purchasing, but also production staff and quality management deal with it!**

Because the cleaning process is more than just a cleaning system, it must be understood and considered as **part of the process chain with the upstream and downstream process steps.**



The basic consideration of cleaning

Most cleaning processes can be characterized by four factors ("Sinner's circle": **time, chemistry, mechanics, temperature**). Depending on the task, these four factors can be combined and adjusted to the production process. **However, it is important to note that changing one factor automatically results in changes with respect to the others.** This means that a shorter cleaning time inevitably leads to a higher proportion of chemistry, mechanics and/or temperature to achieve the same cleaning result. **The cleaning result in turn is significantly influenced by the requirements of the following process step. Here the rule is: *"As clean as necessary, not as clean as possible".*** A cleaning result can be defined as "sufficiently clean" if the subsequent process or the intended function is not negatively influenced by remaining impurities!

Regardless of whether a new cleaning process has to be established or existing plants have to be optimized, **a holistic view of the process chain with regard to cleaning parameters is inevitable**. Ideally, this means the **knowledge (and understanding) of all upstream and downstream process steps**. The process steps before and after a possible intermediate to final cleaning influence each other. Contaminations are introduced, removed, new material sensitivities are generated or requirements for upstream cleaning are made. When solving individual cleaning tasks, it makes sense to place them in an **overall cleaning context.**

This context takes into account the **impurities** to be removed, the **geometry of** the components, their **material properties** and the **requirements** for the cleaning result to be achieved, thus providing a basic overview of the possible cleaning process(es). The catalog of possible contaminations is extremely diverse. It can be divided into **particulate** impurities and **filmic** impurities. Particulate impurities include, for example, chips, dust particles, sand and lint. Filmic impurities include oils, greases, hand perspiration, corrosion protection, coatings, but also adhesives, germs and bacteria in medical technology products. In most cases, the **processes preceding** the cleaning process give **an indication of the type of contamination to be expected**. If, for example, in case of a turning process, it can be assumed that chips and cooling lubricant will adhere and must be removed. The geometry of the components and their condition are also relevant for the selection of the cleaning process. If only a certain functional surface for joining has to be clean, it is usually not necessary to clean the entire component, e.g. by wet chemical cleaning. On the other hand, blasting processes are often mutually exclusive for small individual parts such as screws, as these usually must be treated as bulk material. The cleaning processes are based on a chemical, mechanical or thermal operating principle, so it must be ensured that the cleaning does not cause any damage. Finally, the requirements for the cleaning result have to be defined, which decisively determine the selection of the process as well as the effort and costs. **Basically, a surface is never free of any contamination!**

As already mentioned, the requirements for the cleaning result should depend on the subsequent process steps. **There is no normative specification for a cleaning degree**. A scaled component may well show other impurities after descaling (coarse cleaning). In the case of components of an injection system for engines, the aim of **fine cleaning is** to completely remove particles above a certain size. **Fine cleaning** is necessary in medical technology, the optical industry or even in high vacuum technology because particularly low limits of contamination must be reliably achieved.

Here a part still needs to be formulated that deals with the cleanliness of production and logistics processes. The cleanliness of means of production, especially under the aspect of cross- and re-contamination, is a central planning task when planning a production process and consequently a training requirement for planners, operators and quality managers that should not be underestimated!

Short overview of the cleaning processes

When all relevant facts regarding the cleaning context are collected, a process can be selected or plant manufacturers can be contacted. **Unfortunately, it often turns out that the same procurement routines cannot be put on here as for other manufacturing processes. The cleaning tasks are mostly very complex and multilayered.** There is no universal plant for cleaning in production. The most suitable solution must be determined from a multitude of process variants. Most cleaning technologies established on the market can be divided into wet, blasting, mechanical and thermal processes. In addition, there is a small group of special and customized processes. With a **market share of** approx. **60 %, wet processes** (or "wet-chemical cleaning") are the most frequently used in Germany. This is followed by the blasting processes with a share of approx. 20 %.

Wet processes use water-based cleaners, solvents such as hydrocarbons, alcohols and biological cleaners to dissolve filmic contaminants. To support the cleaning process and to remove particles or chips, the medium is additionally moved by e.g. spraying, flooding or ultrasound, thus achieving a mechanical effect on the surface. Cleaning is often followed by **rinsing processes** to remove impurities and medium as well as **drying**.

The wet processes are very well suited for the **integral cleaning of** many individual parts in the form of **bulk materials or components with complex geometry.**

In the **blasting processes,** angular, round or cylindrical abrasives are accelerated onto the component surface pneumatically (compressed air), hydraulically (water) or mechanically (blast wheel). The impact of the abrasive removes the impurities from the surface. Apart from the blasting medium **dry ice, which sublimates completely dry during processing**, post-cleaning is usually necessary to remove blasting medium residues. The blasting processes are not only used for the purpose of cleaning, but mostly in combination with a simultaneous surface structuring or hardening.

Blasting processes are becoming increasingly popular wherever functional surfaces need to be cleaned and large components need to be treated. Users often neglect the fact that blasting is a purely **visual process**. This means that small bores or complex undercuts are usually difficult or impossible to reach for cleaning.

The mechanical cleaning processes provide information about the underlying cleaning effect simply by their designation. These are elementary cleaning processes such as brushing, grinding, blowing off or sucking or spinning. They can be used manually or automatically to clean bulk materials or individual parts. The advantage of the mechanical processes is the usually very simple and cost-effective plant technology.

Thermal processes include, for example, flame blasting and laser beam cleaning, in which impurities are burned or vaporized. Just like the special processes, which include cleaning with liquid and supercritical CO2, electron beam or UV light cleaning, these processes are chosen for special and sometimes complex cleaning tasks where their specific advantages come into play.

Difficult topic: quality assurance

If requirements have been defined in the course of process selection and analysis of the cleaning task, it must **also be possible to measure or prove the specified degree of cleaning.** Likewise, the parameters of the cleaning process, such as the plant parameters as well as input and output variables must be **monitored** and, ideally, **logged.** Here, the cleaning behaves identically to other production and manufacturing processes. A change of the parameters inevitably leads to a change of the cleaning result, which in the worst case can lead to quality problems in the following work step. While the monitoring of cleaning parameters is easy to set up with the current state of process and plant technology, the **verification of cleaning results** is **much more difficult**.

Particulate contamination can still be easily detected microscopically on the component or in the rinsing fluid. Filmic contaminations, on the other hand, are difficult to detect in the process without contact. Methods such as test inks, wiping and water run-off tests allow an assessment, but the component surfaces are again contaminated in the process. In order to achieve consistent cleaning results, it is necessary to adjust the cleaning processes precisely to the contaminants to be removed and to ensure a more or less uniform **introduction of impurities into the cleaning line.**

Cleaning - at a glance

Cleaning is part of the product creation process and must be considered as such in the value-added process. **By definition, cleaning is not value-adding, but it is usually obligatory and maintains value.** In the end, a contaminated component is useless for further processing. Before investing in new processes and equipment, the optimization of cleaning lines must be examined. **At least basic staff training and careful handling of cleaning parameters in production should be among the first measures to be taken in the event of problems with cleanliness in production.** The cleaning processes, like other production processes, must be carefully planned and implemented. The available cleaning processes have specific advantages and disadvantages, which means that they must be adapted to the specific task and the requirements for the cleaning result must be precisely defined.

When planning a cleaning process, it is therefore important to include the upstream and downstream work steps and to consider the monitoring of the processes and results. **Comprehensive knowledge and understanding of the important influencing variables is, however, a basic prerequisite for cleaning-oriented production.**