Fraunhofer
CLEANING

CLEANING TECHNOLOGY

Customized approaches to clean products and processes

In research and development, the technology involved in ‘cleaning’ is a good deal more sophisticated than our common associations with the term would suggest. The cleaning of components or products in industrial production was seen for a long time merely as an unavoidable cost factor that inevitably had to be accounted for somehow. Attitudes today are fundamentally different, guided by two aspects of high-tech cleaning technology that have awakened interest and furthered its importance to industry.

The first concerns those companies who supply reliable high-performance cleaning technologies and machines. We expect our food and medicine, for example, to be produced and packed in hygienically immaculate production facilities. Modern technology – and even robots – are increasingly used to preserve cleanliness in the home, at work or in public places and facilities. These technologies help us to achieve the standards of hygiene and cleanliness we have come to expect today, at a reasonable cost.

The second aspect involves industrial production itself. Taking protective coatings as an example, these will only serve their function over an extended period of time if they have been applied to surfaces that have been thoroughly cleaned. Components can only be manufactured with the necessary precision if they are free of impurities in the critical phases of production. In the final analysis, sensibly integrated cleaning technology lowers production costs by improving product quality and reducing rejection rates.

Our understanding of cleaning technology encompasses the comprehensive range of products and services we are able to offer you.

We would welcome the opportunity to tell you more about how we can help you tackle new solutions in production and in other areas of your company.

We look forward to your call and will be pleased to advise you.

Hans-Jörg Bullinger
President of the Fraunhofer-Gesellschaft

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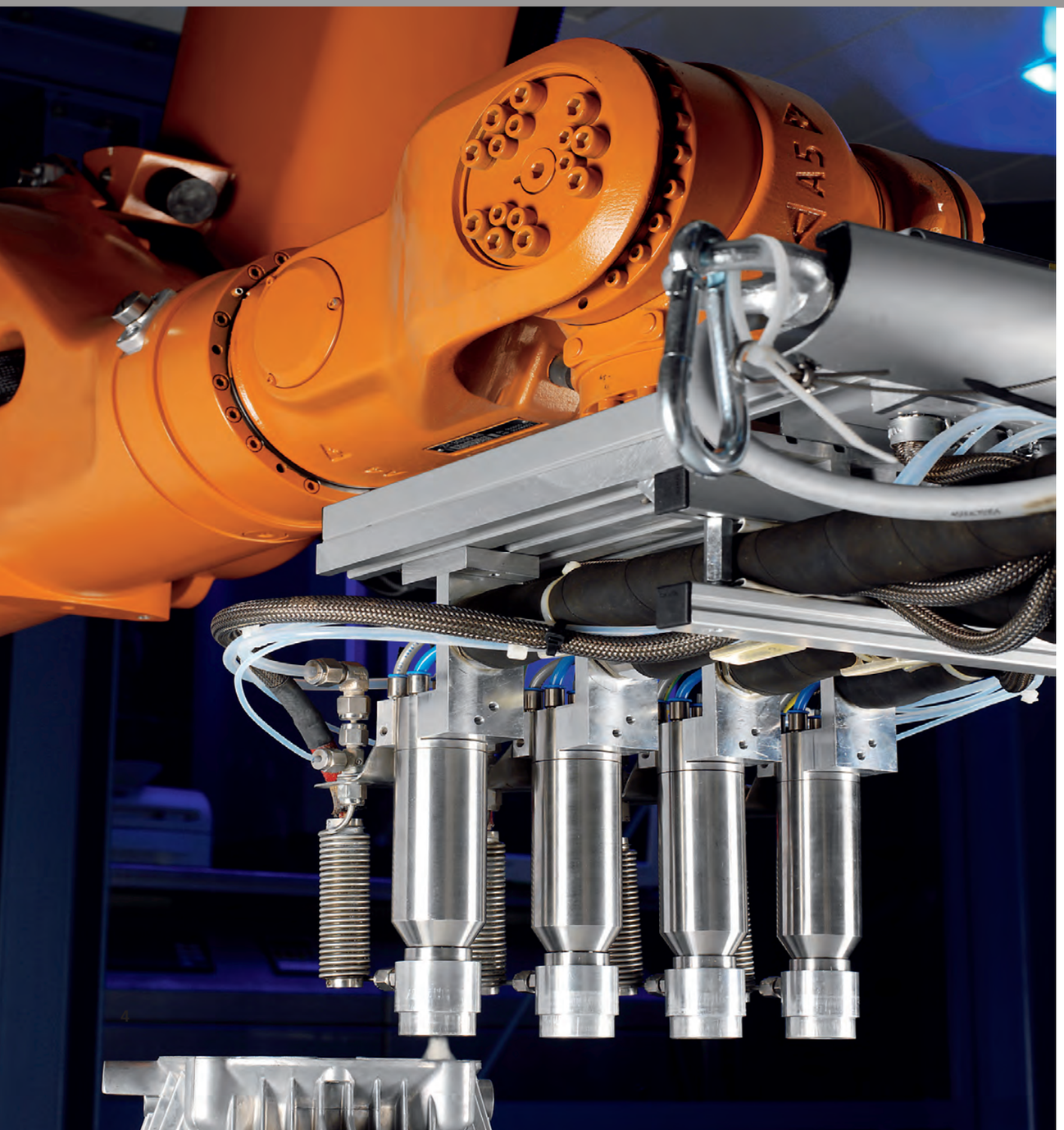


CLEANING TECHNOLOGY ENCOMPASSES ALL SECTORS OF INDUSTRY. THANKS TO ITS BROAD EXPERIENCE AND EXPERTISE IN ALL AREAS OF APPLIED RESEARCH, THE FRAUNHOFER-GESELLSCHAFT IS IDEALLY SUITED TO PROVIDE COMPREHENSIVE ADVICE AND SOLUTIONS IN THIS SPECIALIZED TECHNOLOGY.

COMPLETE SOLUTIONS FROM ONE SOURCE

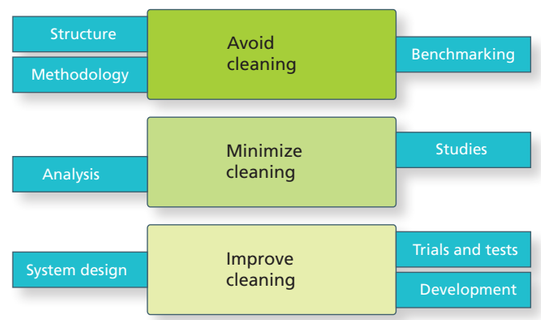
The cleaning technology process chain is more than just different cleaning processes. Upstream processes serve to prevent contamination or reduce the complexity and cost of cleaning. Downstream the technology monitors how effectively cleaning processes function in quality assurance, at the same time controlling the environmentally compatible disposal of impurities and contaminants and the cleaning agents used to remove them. Fraunhofer institute expertise covers the entire cleaning technology process chain.

It is pooled and coordinated in the Fraunhofer Cleaning Technology Alliance, covering the entire spectrum of cleaning technology across all processes. The Fraunhofer institutes thus provide an unparalleled range of services in this field to industry throughout Germany.

Cooperation with the institutes helps customers to find answers to questions that need urgent attention. But the solutions ultimately enhances market success, too: sophisticated cleaning management and the complete integration of cleaning in the manufacturing process chain bring down costs, while seamless and thoroughly tested cleaning processes increase the quality of the final product and thus market acceptance. Output that fails to meet quality standards is minimized.

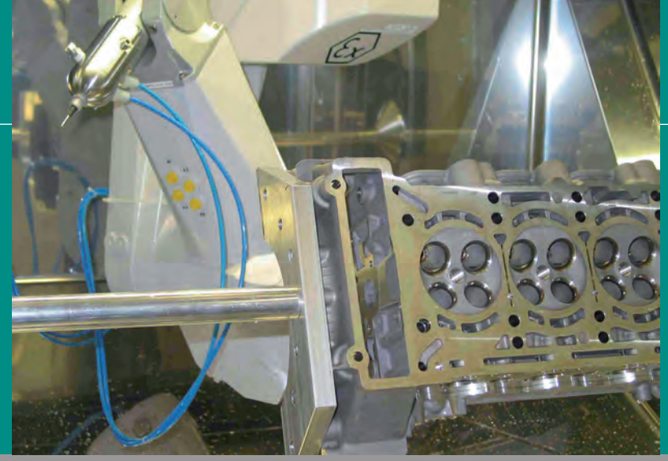
The independence of the Fraunhofer institutes when evaluating cleaning procedures and systems guarantees solutions that respond to actual needs. As environmental protection stipulations are also always taken into consideration, the optimization of cleaning processes ultimately contributes to the company's improved business performance.

Activites undertaken by the Fraunhofer Cleaning Technology Alliance can be classified into three core categories. These focus on the need to avoid, minimize and improve cleaning processes.



ACTIVITIES ARE FURTHER DIVIDED INTO SEVEN AREAS OF APPLICATION:

- INDUSTRIAL CLEANING OF COMPONENTS AND SEMI-FINISHED PRODUCTS
- CLEANING IN MAINTENANCE AND REPAIR
- PRE-TREATMENT OF COATED SURFACES
- CLEANING IN MICROSYSTEMS ENGINEERING
- CLEANING HYGIENICALLY CRITICAL AREAS
- PRESERVATION OF CULTURAL HERITAGE
- EDUCATION AND TRAINING



BUSINESS AREAS

»A HOLISTIC VIEW OF CLEANING AND ITS INTEGRATION IN MANUFACTURING PROCESSES IS A PREREQUISITE FOR HIGH-QUALITY PRODUCTS.«

1. INDUSTRIAL CLEANING OF COMPONENTS AND SEMI-FINISHED PRODUCTS

Component cleaning as added value

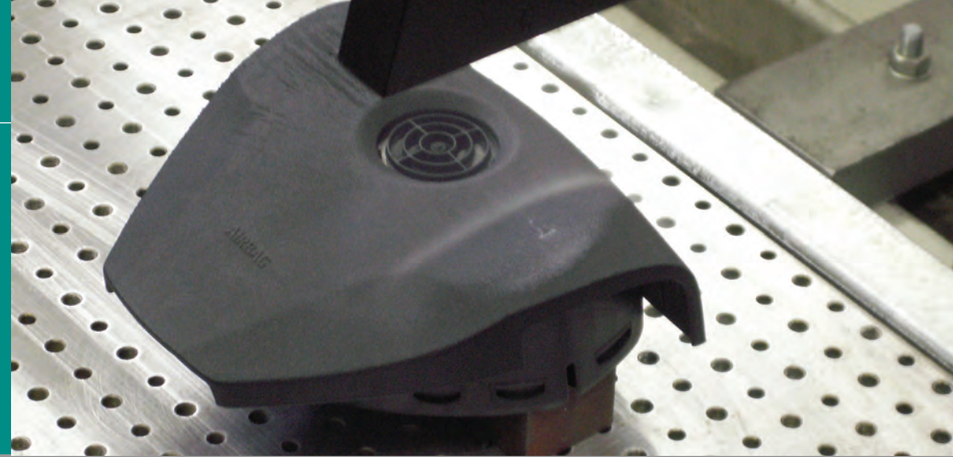
Superior quality in manufacturing is absolutely dependent on the technical cleanliness of semi-finished products, components and their functional surfaces, as well as the conditions under which production takes place. System components are shrinking in size even as they become technically more complex. Cleaning processes, as a result, are becoming increasingly elaborate and costly. Residual contaminants on components not only impair the functionality of technical systems; they also increase the rate of rejected production output, which pushes up manufacturing costs. Ensuring components are clean therefore adds substantial value to the manufacture of components and assemblies. The need to make better use of available cleaning technologies is not merely a consequence of cost considerations, however, as is readily seen through the enforcement of increasingly stringent legislation to protect the environment – in itself a response to a growing awareness of environmental issues.

Integrating cleaning into the manufacturing process

Industry often views the cleaning of components as a necessary evil. Manufacturers are frequently tempted to simply tack cleaning on to the end of existing production lines, if this is at all possible, rather than integrating cleaning into a comprehensive view of the entire production process. Such integration, however, is imperative to maintaining both competitiveness and exacting quality standards, especially when profit margins are low. The Fraunhofer Cleaning Technology Alliance has generated various ideas, concepts and solutions that allow cleaning and production to be viewed as a closely matched entity, one that makes cleaning a welcomed and useful contributor to added value. Our approach is divided into three phases: A look at ways to avoid cleaning, is followed by possible approaches to minimizing the cleaning required, and finally how to improve the effectiveness of cleaning processes.

MAIN AREAS OF FOCUS

- *Integrating cleaning into production*
- *Automation of cleaning processes*
- *Cleaning technologies*
- *Analysis*



»CLEANING IS A CRUCIAL PART OF ALMOST EVERY MAINTENANCE TASK. WITHOUT CLEANING A LOT OF MAINTENANCE WORK CANNOT BE PERFORMED PROPERLY.«

»SUFFICIENT ADHESION OF COATINGS AND ADHESIVES CAN ONLY BE ENSURED BY PRIOR CLEANING AND PRE-TREATMENT.«

2. CLEANING IN MAINTENANCE AND REPAIR

An integral part of the maintenance process

Cleaning is a part of every maintenance and repair process and is essential to proper operation. In most cases, cleaning is the first step when servicing and maintaining machines and equipment. Without first removing contaminants, inspection, diagnosis and repair cannot be performed. The cleaning of machines and equipment can often be classified by the following objectives and requirements:

- Visual
- Preventative and
- Functionally relevant

Cleaning is employed to remove visible layers and dirt, and to restore the appearance of the original. Preventative cleaning aims to maintain operational efficiency, in order to avoid costly repairs and to reduce the downtimes of machines and equipment. When relevant to proper operation, cleaning may involve the removal of functional coatings prior to their renewal as part of manufacturing and repair.

Cleaning that addresses issues

In addition to the high processing, treatment and disposal costs, the often manual cleaning processes impose a burden on the environment, on the health of workers and on the components themselves. Many cleaning methods are the target of public criticism and more stringent environmental requirements. Growing importance is therefore being attached to cleaning processes that can easily be adapted to tackling the specific problems being faced in a more ecologically efficient manner.

MAIN AREAS OF FOCUS

- *Cleaning strategies for maintenance and repair*
- *Development of task-specific cleaning technologies*
- *Reduction of cleaning-related downtime*

3. PRE-TREATMENT OF COATED SURFACES

Functional layers

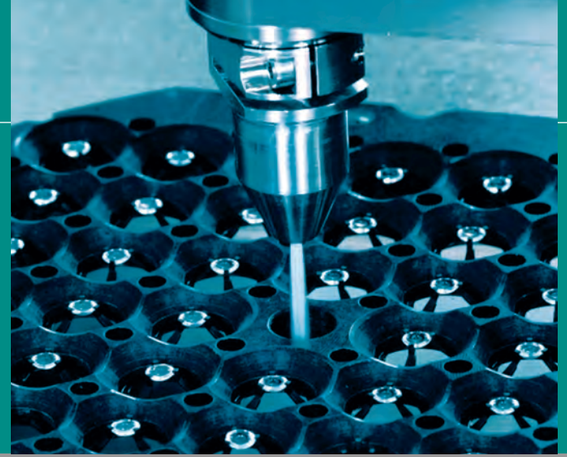
The surface plays a decisive role in enabling engineered materials to fulfill their purpose. For this reason, numerous coating technologies are used to create or improve functions performed by the surfaces of various base materials, such as reducing friction, protecting against wear or corrosion, or even adding decorative attributes. Functional coatings often deliver a crucial market advantage, which is why appropriate coating technologies can be found in almost all industries today. But if these coating systems are to adhere properly, they can only be applied to surfaces that have been pre-treated using the appropriate cleaning technology. Components from industrial production, which makewhich make their way through many different manufacturing steps under sometimes 'harsh' conditions, must therefore be rid of impurities – sometimes down to even molecular level.

Cleaning

In applications involving layer technologies, inadequate pre-treatment leads to failure of the layer and, ultimately, to the failure of the entire component in most cases. Efficient cleaning not only has to consider the products to be cleaned, which are composed of various materials such as metal, ceramics, glass or plastic, but also the contamination to be removed. Impurities on surfaces can include emulsions, oils, grease, metals, shavings, flux, soldering paste, scale layers, rust, oxides, salts and other particles. The cleaning task is also very precisely defined by requirements that the surface must later fulfill. In addition to intensive and careful cleaning and the removal of impurities, attention is often focused on the activation or passivation of material surfaces in preparation for subsequent processing. Companies have to rely on the existing concepts of equipment manufacturers, which are generally not adapted to their specific manufacturing operations, or simply do not offer a complete solution for a cleaning task.

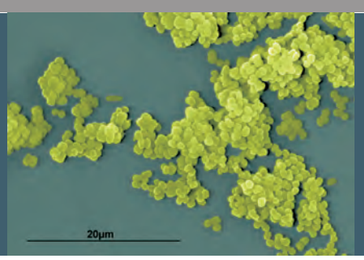
MAIN AREAS OF FOCUS

- *Cleaning and pre-treatment techniques*
- *Coatings that facilitate cleaning*
- *Analysis*



» THE MANUFACTURE OF MICROSTRUCTURES AND MICROCOMPONENTS REQUIRES A HIGH DEGREE OF CLEANLINESS ACROSS THE ENTIRE PRODUCTION PROCESS.«

» IN AN AREA IN WHICH CLEANLINESS IS PARAMOUNT, DESIGNS TAILORED TO CLEANING REQUIREMENTS CAN SHORTEN DOWNTIMES AND MAKE THE CLEANING OF PRODUCTION EQUIPMENT MORE EFFECTIVE.«



4. CLEANING IN MICROSYSTEMS ENGINEERING

No microfunction without nanocleanliness
It is no longer possible to imagine our daily lives without electronic aides, for example, in cars. More and more functionality is expected from these products, leading to increasing miniaturization of their electronic and mechanical systems. During their manufacture, even the tiniest particle of dust can impair the quality or operation of such miniaturized systems, or lead to their complete failure. If the required cleanliness in not upheld over the entire manufacturing process, these systems will never be able to serve their intended purpose for the user.

A provider of research and service in clean production
The high demands placed on cleanliness when manufacturing micro-engineered systems are very familiar to the scientists of the Fraunhofer Alliance. Thanks to cooperation within the Alliance across all relevant technological disciplines, there is always an expert with the right qualifications and experience on hand to tackle problems or questions in any field, making use of the enormous potential existing in available analytical and manufacturing engineering infrastructure.

MAIN AREAS OF FOCUS

- *Cleanroom technology*
- *Avoid and minimize cleaning requirements*
- *Clean production*

5. CLEANING HYGIENICALLY CRITICAL AREAS

Quality through hygiene
The absolute adherence to hygienic practices in the production of goods such as foods, medical engineering equipment, life science and biotechnology products is the focus of growing public interest. Legislation has enforced lower and increasingly more specific tolerance limits in these areas, leading to more exacting requirements for cleanliness. Clean, hygienic or even sterile production environments, or a corresponding control of the final products' quality and standards of cleanliness, thus take on pre-eminent significance in the manufacturing process.

Hygiene integrated into production
Hygienic standards required of the final product can be achieved by the cleaning, disinfection or even sterilization of the end product. It frequently turns out, however, that when 'cleanliness' is integrated into production by hygienic design of the facility, this can reduce or even prevent complex and costly 'end-of-the-pipe' solutions. The cleaning and disinfection of the production facility can also be carried out more effectively, thus reducing downtimes.

MAIN AREAS OF FOCUS

- *Cleaning strategies for hygienic production*
- *Disinfection and sterilization*
- *Electron beam processes*

»MODERN CLEANING TECHNIQUES HELP PRESERVE CULTURAL HERITAGE.«

»SUCCES BUILT ON THE RESEARCH KNOW-HOW OF THE FRAUNHOFER CLEANING TECHNOLOGY ALLIANCE.«

6. CLEANING FOR CULTURAL PRESERVATION

Old, but clean

A lot of time and expense goes into the restoration of historically valuable cultural artifacts. The first step in the preservation process generally involves the careful cleaning of the surfaces to be restored. Very old materials, and open questions regarding the mix of material and dirt, make it difficult to choose the appropriate cleaning technology. Decades of restoration experience can compensate for this lack of information. An attempt at restoration that fails, however, is usually also the final attempt.

More recently, works of art that are less than 50 years old have become candidates for restoration. These works are made out of materials such as plastic, and no experience has been gained until now in how they can be restored. There is a growing need to develop techniques in this area, and it is here that the experience of the member institutes of the Fraunhofer Cleaning Technology Alliance can provide the requisite building blocks, through their work in the development of modern materials as well as their comprehensive analytical capabilities.

Clean and durable

In the past, cultural artifacts have often been restored and cleaned several times. Cleaning often led subsequently to an accelerated deterioration of the materials, caused by chemical changes to the surface, precipitated by the cleaning itself or by cleaning chemicals that could not be entirely removed. A unique combination of expertise in almost all methods of cleaning technology and surface analysis is further complimented by wide-ranging experience in the development and modification of materials, and in surface treatment, to provide excellent opportunities for interdisciplinary work on restoration issues.

MAIN AREAS OF FOCUS

- *Analysis*
- *Blasting techniques*
- *Special methods*

7. EDUCATION AND TRAINING

The crucial role played by cleaning in manufacturing is becoming ever more apparent. Cleaning technology is an integral part of the manufacturing process chain and an interdisciplinary topic of relevance to mechanical and plant engineering as well as in manufacturing and process engineering. There is often a lack of systematic approach and methodology when analyzing cleaning issues or selecting cleaning techniques. It has not been possible up until now to gain relevant expertise through vocational training or a course of study, resulting in a lack of know-how and trained employees in industry. An accordingly high demand exists for training courses and seminars. A survey, carried out to analyze the market and future trends, revealed that 20% of the companies firmly intend to train their employees.

This has prompted the Fraunhofer Cleaning Technology Alliance to offer various basic and advanced training courses, such as the seminar ‘Cleaning technology – cleaning in manufacturing,’ which introduces participants to basic principles. Industry research groups and seminars on specific topics are also organized.

The Fraunhofer Cleaning Technology Alliance is responding to the demands of industry by transferring its knowledge of methodical and systematic approaches to cleaning technology.

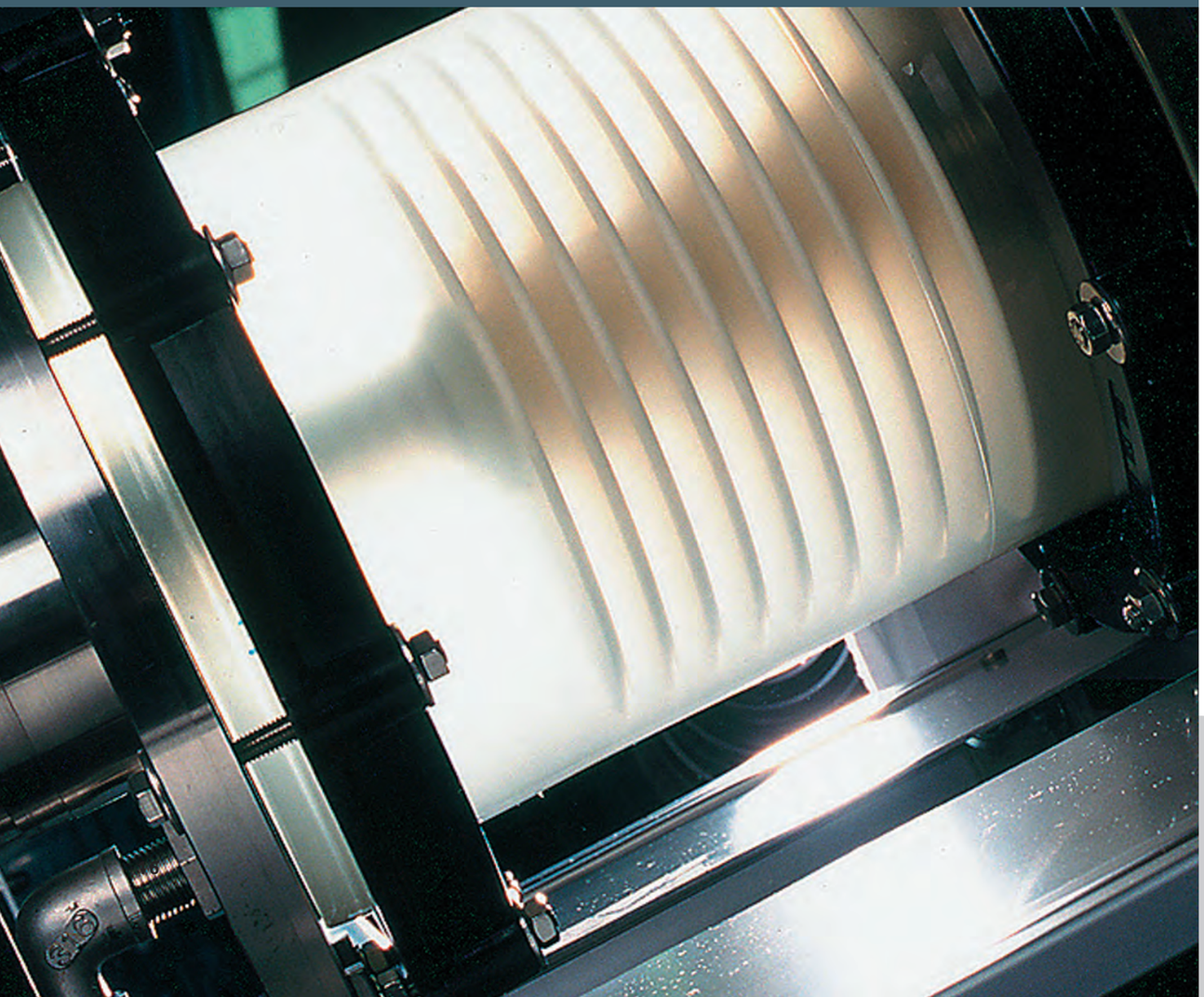
MAIN AREAS OF FOCUS

- *Seminar: Cleaning technology principles*
- *Training courses on residual contamination (according to VDA 19 [approx. equivalent to ISO 16232])*
- *Topic-specific industry workgroups*

THE CLEANING TECHNOLOGY ALLIANCE MAKES IT POSSIBLE TO POOL EXPERTISE AND TO MAP THE ENTIRE CLEANING TECHNOLOGY PROCESS CHAIN, INCLUDING ALL UP AND DOWNSTREAM PROCESSES.

- PROCESS ANALYSIS AND CONSULTING
- CLEANING TECHNOLOGIES
- SYSTEM DEVELOPMENT, EQUIPMENT AND COMPONENT MANUFACTURING
- PROCESS AND FAILURE ANALYSIS
- PARTICLE ANALYSIS AND CLEANLINESS CONTROL
- QUALITY ASSURANCE

EXPERTISE



1. PROCESS ANALYSIS AND CONSULTING

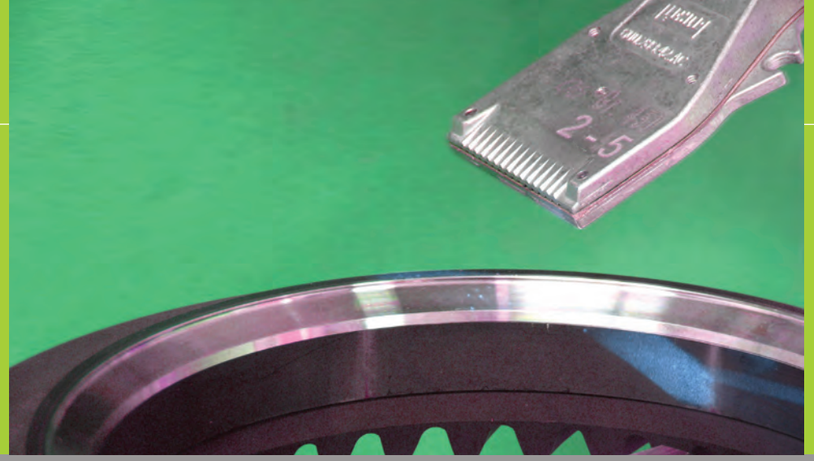
We offer customers structured and efficient solutions to problems in consulting them on the selection of cleaning processes and technologies. Our innovative and structured search for ideas is based on methods applicable to innovation management. These methods are also implemented in our highly efficient documentation of problem-solving processes. Simulation techniques represent another important tool. Measures are evaluated not only by testing equipment prototypes but also by simulating clean manufacturing, processes and equipment.

Taking the results of a root cause analysis as a starting point, we draw up proposals for improving production workflow, processes, staff deployment, cleaning and quality assurance methods. These are based on an approach in which we first look at measures that can avoid or reduce the occurrence of contamination. Where avoidance or reduction are not possible, measures and methods for removing the contamination are subsequently investigated.

The consulting services of the Cleaning Technologies Alliance are based on a modular system it has developed to efficiently perform integrated assessments of cleaning processes in all crucial sub-areas of the manufacturing workflow. In order to do justice to the demands of an integrative assessment, these analyses consider cost-effectiveness in addition to technological and ecological concerns.

2. CLEANING TECHNOLOGIES

The Cleaning Technologies Alliance has a variety of cleaning technologies available for industrial cleaning that can be selected, adapted and put to use as needed. Cleaning technologies range from mechanical jets, such as dry-ice jets, compressed air jets with solid blasting agents, water jets and abrasive water jets, as well as plasma cleaning methods, laser beam cleaning through to non-enclosed non-thermal electron beam processes and wet-chemical cleaning methods such as ultrasound and spray cleaning.
Our cleaning technologies make it possible to carefully clean away the slightest contamination in the form of particles and films, through to the removal of old, disruptive or functional layers. In addition to chemical, mechanical and thermal techniques, the Alliance also offers other important cleaning technologies that have been gaining ground in recent years, including laser



beams, CO2 jets, plasma techniques and electron beams. This is attributable not only to the benefits gained through these individual technologies – including greater precision, better protection of the substrate and lower heat transfer to the base material. These technologies also respond to increasingly tougher legislative regulations regarding the maintenance of hygiene and avoidance of waste and pollutants.

The Cleaning Technology Alliance is able to tackle a range of parts that extends from highly sensitive components for the chip industry through to the huge parts handled by forming technology. The Cleaning Technology Alliance is able to optimize the processes involved in a variety of cleaning techniques, improving their cost-effectiveness and contributing decisively, through added value, to the competitiveness of the companies concerned.

3. SYSTEMS DEVELOPMENT, EQUIPMENT AND COMPONENT MANUFACTURING

In order to be able to react flexibly to changing markets, customers of the Cleaning Technologies Alliance can provided with autonomous and modular turn-key solutions for cleaning systems. The expertise of the participating institutes is demonstrated by their systematic approach to defining a concept, followed by the design and implementation of cleaning systems and their sub-systems. In providing integrated solutions, the Alliance implements a modular architecture that allows components to be used in existing equipment and systems and in those to be developed.

Application-specific cleaning devices and equipment are designed and constructed according to process developments. This involves developing application-specific laser and electron beam sources with customized beam guidance and beam-shaping systems, developing and building nozzles used in blasting processes, drawing up concepts for mechanical, electrical and data processing interfaces, as well as measures to integrate modules into existing manufacturing systems.

In addition to these developments, online and in-situ methods for process control, quality assurance and to ensure process reliability are also provided.

4. PROCESS AND FAILURE ANALYSIS

Contaminants such as particles, oily films and other undesirable substances not only impair the appearance of a workpiece but also its ability to be processed further and to perform its final intended function. Increasing demands on functionality and reliability, the pursuit of zero-defect quality targets and, last not least, the improvement of existing products, all call for greater use of surface analysis techniques. These analyses are used to identify the causes of disruptions or the source of particles or filmy residues, and to maintain full control of the production process at all times.

The contaminants to be analyzed are frequently invisible to the eye. The analysis methods and measuring techniques employed to characterize engineered surfaces depend on the task at hand. In failure analysis, various methods are used to systematically isolate the cause of the disruption and its source and, if necessary, to reproduce it. A comparison of ‘good’ and ‘bad trials’ will often provide the first indication of where the fault lies. The method selected to analyze series production will depend on criteria that determine ease of handling, operational management considerations, and how this continuous monitoring procedure is to be integrated into the process work flow. Natural science and engineering institutes cooperate to make a variety of analytical methods available for characterizing the degree of cleanliness of cleaned component surfaces. These methods, which are also suitable for small-scale sample runs, work at very high spatial resolutions to detect the smallest traces of contamination. The Cleaning Technology Alliance offers a wide range of microscopic and spectroscopic characterization methods. Alongside post-cleaning analytical characterization methods, the Alliance also provides services that focus on a variety of in-situ testing methods that can be integrated into processes.

5. PARTICLE ANALYSIS AND CLEANLINESS CONTROL

The degree of cleanliness required for components and assemblies has risen steadily over the past few years, particularly in the automotive and medical engineering sectors. Functional quality is directly linked to the existence of particle contamination, and its quantitative detection in any component depends on the testing methods used. Even the most minute particle contaminants can cause a component or an assembly unit to fail, and this in turn can lead to the failure of the machine, or the entire technical installation.

Cleanliness inspections measure any and all relevant particle contamination originating from the manufacturing process and production environment, wherever these particles exist on surfaces which affect the component's function. However, there are no definitive methods available to check cleanliness. Due to the wide variety of components in question, and the complex geometries involved, it is rarely possible to carry out measurements that will determine how clean a component is, especially since its functional areas are often enclosed. An indirect multi-stage procedure is carried out as stipulated by guidelines for testing technical cleanliness (VDA 19 [approx. equivalent to ISO 16232]), whereby customized test-engineering solutions can also be employed to satisfy extensive and varied cleanliness requirements.

The Cleanliness Technology Alliance is a competent and powerful partner to industry in the area of technical cleanliness. Assignments involving particle analysis and cleanliness control are carried out by qualified personnel in a wide range of testing and analysis facilities that exceed today's state-of-the-art.

6. QUALITY ASSURANCE

Replicable product quality depends on reliable processes. Knowledge of the crucial parameters influencing cleaning processes, and the ability to maintain full control of the process at all time, belongs to the key know-how required to plan and secure processing capability. A comprehensive quality assurance strategy for the cleaning chain is required to ensure that the cleaning results achieved remain unaltered on their way to the end user, or to the next step in the manufacturing process. Quality assurance encompasses the original condition of the object to be cleaned, the cleaning itself, inspection after cleaning, and subsequent steps in the manufacturing process and logistics.

Quality assurance and inspection are therefore given high priority in cleaning technology, which therefore forms a core area of activity for the Cleaning Technology Alliance. The Alliance supports its customers' quality assurance in their manufacturing processes by taking an all-encompassing view of the process chain, including development and selection of online measurement procedures and the elaboration of cleaning concepts that focus on the need to control and maintain quality at all times.

OUR SERVICES

The Fraunhofer service system

The Fraunhofer Cleaning Technology Alliance makes a decisive contribution to the further development and industrial use of cleaning technologies. Small and medium-sized companies, in particular, make use of the expertise provided, but major corporations also call on us for support. You, too, can benefit from the comprehensive expertise of the Fraunhofer Alliance in the analysis and experimental development of cleaning methods and processes.

The services we offer center around our development and implementation of the innovative concepts, techniques and solutions that make cleaning processes efficient and competitive. Our wide-ranging expertise encompasses diverse areas in which the optimization of procedures and processes enable performance and competitive potential to be used to the full.

Our services include in-depth solutions and extend all the way through to the optimization of complex cleaning workflows. Take advantage of our range of services:

- Market and trend analyses
- Feasibility studies
- Contract analyses
- On-site technology assessment
- Methods, process and technology development
- Retrofit and optimization of existing technologies and equipment, testing of methods and procedures under production-related conditions using the most modern equipment
- Services and technology support
- Cost-efficiency analyses
- Training courses and seminars
- Information on suitable funding opportunities (German Land, federal and EU funding)

COOPERATION

with the Fraunhofer Cleaning Technology Alliance

We can offer you a wide range of alternatives for cooperation, and can adapt the selected form to your specific requirements.

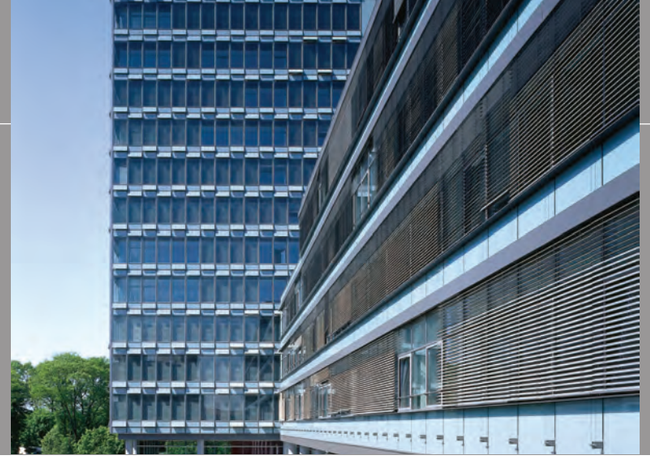
Strategic pre-competitive research

Publicly financed pre-competitive research is devoted to the initial and further development of future technologies and markets. Our cooperation partners in industry benefit from the know-how we acquire outside of contract research.

Bilateral and multilateral industrial projects

Research and development assignments provide an effective opportunity to drive the innovation process forward in the companies involved. We develop solutions for our customers that are commercially sound when put into practice. Any questions raised are dealt with individually and competently. We consult with our partners to determine the desired level of complexity, time scale, and scope of research involved in the project, and agree with them on non-disclosure.

PLEASE GET IN TOUCH WITH OUR OFFICE AND OUR STAFF REPRESENTATIVES FOR MORE INFORMATION ABOUT THE FRAUNHOFER CLEANING TECHNOLOGY ALLIANCE'S RANGE OF SERVICES OR FOR DIRECT ANSWERS TO ANY SPECIFIC QUESTIONS YOU MAY HAVE.



FRAUNHOFER-GESELLSCHAFT

The Fraunhofer-Gesellschaft conducts applied research for the immediate benefit of private enterprise and for the greater good of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration. Commissioned and funded by German federal and state ministries and agencies, forward-looking research projects are carried out that contribute to innovation that addresses public needs and those of business.

Fraunhofer Institute technology and system-oriented innovations for their customers contribute to the competitiveness of the region, Germany and Europe. In doing so their aim is the economic, social and ecological development of society.

The Fraunhofer-Gesellschaft offers its employees a platform for professional and personal training for positions of responsibility in their institutes, in private enterprise and in other areas of science.

At present, the Fraunhofer-Gesellschaft maintains more than 80 research institutions, including 60 Fraunhofer Institutes, at locations throughout Germany. About 17,000 employees, the majority of whom have degrees in science or engineering, work with an annual research budget of 1.5 billion euros. Of this sum, approx. 1.3 billion euros is in the area of contract research. For about two-thirds of this contract research, the Fraunhofer-Gesellschaft generates revenues from contracts with industry and publicly financed research projects. A third is funded by the German federal government and the Länder in order to give the institutes the ability to come up with solutions that will be needed by business and society in five or ten years.

Research facilities in Europe, the U.S. and in Asia ensure contact with the most important science and economic areas of the present and future.

PUBLISHING NOTES

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