Adhesive bonding technology

Key technology for a competitive advantage

Fraunhofer Institut Fertigungstechnik Materialforschung
Fraunhofer-Gesellschaft (FhG)
Research partner for industry

The Fraunhofer-Gesellschaft is the leading organization for institutes of applied research in Europe. At present, the Fraunhofer-Gesellschaft maintains some 80 research units, including 56 Fraunhofer Institutes, at over 40 different locations in Germany. The majority of the roughly 13 000 staff are qualified scientists and engineers, who work with an annual research budget of over 1.3 billions euros. Of this sum, more than 1 billion is generated through contract research. Roughly two thirds of the Fraunhofer-Gesellschaft’s contract research revenue is derived from contracts with industry and from publicly financed research projects. The remaining one third is contributed by the German government, partly as a means of enabling the institutes to pursue more fundamental research in areas that are likely to become relevant to industry and society in five or ten years’ time.

The Adhesive Bonding Technology business field is concerned with the development and characterization of adhesives, the optimized design and simulation of bonded and hybrid joints and their testing and qualification. The planning and automation of adhesive bonding at an industrial scale are also carried out. Further areas of work are process reviews and the provision of certified training courses in adhesive bonding technology.

The Surfaces business field is split into the work groups Plasma Technology and Paint/Lacquer Technology. Customized modification of surfaces – for example pretreatment of surfaces prior to bonding or coating and corrosion protection coatings – considerably extends the range of uses of many materials.

One area of work which extends to both these business fields is Surface and Interface Analysis. The fundamental knowledge acquired here contributes to the effectiveness of bonded joints and coatings.

The Department of Adhesive Bonding Technology and Surfaces of the Fraunhofer Institute for Manufacturing Technology and Applied Materials Research is the largest independent research group in Europe working in the area of industrial bonding technology. Over 140 employees are actively engaged in applied R&D work in adhesive bonding technology and surface technology. The scope of the work extends from fundamental research right through to production and market introduction of new products. The industrial application fields are chiefly vehicle manufacture and mechanical engineering, energy technology (principally wind and solar energy), micro-production and the packaging and electrical industries.

The Department of Adhesive Bonding Technology and Surfaces is certified in accordance with DIN EN ISO 9001 and the material testing laboratory is also accredited in accordance with DIN EN ISO/IEC 17025. The Center Adhesive Bonding Technology is an internationally recognized organization for providing employee training courses in adhesive bonding technology and is accredited by the DVS-PersZert in accordance with DIN EN ISO/IEC 17024.
Adhesive bonding technology has assumed a permanent place in virtually all areas of life. For some time people have also relied on the effectiveness of bonding in many safety-related applications – for example in aircraft and cars.

**Flexibel, practical, gentle**

Joining techniques such as welding, brazing, riveting and screwing are used by industry all over the world on a daily basis. A further method of joining has also proven to be highly successful: adhesive bonding. Known for thousands of years, this method has become as important as the other joining techniques as a result of the pace of developments in recent years. In many areas, this bonding technology has even become a key technology: New, hitherto unrealisable combinations of materials, as well as the need for the highest requirements for connections, have made this flexible joining technique the preferred technology, especially in high-technology areas. In hybrid-joining, the unique advantages of using adhesives are combined with the benefits of other joining techniques.

Adhesive bonding technology has an extremely broad range of applications. IFAM is opening up the potential of this joining technique via its intensive research and development work.

**Many advantages for new products**

Virtually all solid materials can be connected with one another using adhesives – for example glass with metal and ceramic with plastic. High temperatures are not required in the joining process. That is beneficial for the materials and prevents shape-distortion. Additional functions such as corrosion protection, vibration damping, electrical conductivity and sealing to liquids or gases can be integrated into the bonded connection.
Modern adhesive bonding in everyday industrial use

Example, shipbuilding: For connecting polycarbonate outside windows with the aluminium frames, an adhesive which has an optimum combination of adhesion and strain properties was developed with the assistance of IFAM. As a result of the expert design of the connection, a solution was produced whereby the panes bend when subjected to loads – but not so much that the applied scratch-protection coating breaks away.

Know-how from a single partner

As Europe’s largest independent research organisation in the area of bonding, IFAM’s work covers all aspects of bonding technology. All key areas are worked on under one roof. Practical and effective applications result from our expertise in introducing adhesive bonding technology into everyday industrial use and from practical implementation of our latest R&D results.

From development to production

If no suitable adhesive is available in the marketplace for a special application, IFAM develops and formulates an appropriate adhesive – based on the requirements of the customer. One way of doing this is to modify an existing product. If this does not turn out to be promising, a completely new adhesive can be developed. Our sound knowledge of the chemistry of adhesives and wide experience of practical industrial applications guarantee an optimum solution. The up-scaling – namely the manufacture of larger amounts of the newly developed adhesive – naturally forms part of our work. IFAM is also active in the still new but promising field of biological inspired adhesives.

Regarding the designing of adhesive bonded joints, optimum solutions which meet all requirements are determined. For example, the mechanical loads which act on the connections are investigated as are the effects of liquids, gases, heat, electric current and light. Computer simulations and tests on standard samples give information about the optimum geometric design of the bonded joint, with the strength under continuous loads being the most important criteria. The simulation results are then verified by means of load tests on pseudo-components.

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(top and middle) Set-up of measuring instruments and FEM-simulation: Investigation of new construction methods for rail vehicle construction. The sample component was affixed using rubber-elastic and elastic-plastic adhesives.

(bottom) Reactor for chemical syntheses. Following the development of a raw material required for a specific application there is stepwise scale-up of the manufacturing process.
Adhesive bonding of oiled steel sheets, which was impossible in the past, has become an everyday application in the car industry. The adhesive and the oil are matched exactly to each other – a ground-breaking development in which IFAM played a leading part.

The successful realization of bonded connections in industrial production requires precise planning of the individual production stages. The joining process must be compatible with previous, subsequent and concurrent production stages. The handling of the parts to be joined is just as important as adapting the technology for applying the adhesive to the use: feeding, mixing, dosing and applying. In micro-assembly, for example, the correct application of a few trillionths of a litre of adhesive is a huge challenge. The combination with other joining techniques is also of key importance. The various options for the hardening step must be taken into account at the planning stage.

For high-quality connections, special pre-treatment of the surfaces to be bonded is often necessary. The materials to be bonded are cleaned and activated or modified so that adhesives can adhere better to them. This also gives the surfaces to be joined protection against corrosion. An example is the pre-treatment of aluminium for aircraft construction.

IFAM provides extensive consultancy on all matters relating to bonding technology. Included here is the design of the workplace tailored to the application, taking into account work safety regulations. We also give training in the correct handling of adhesives.
Characterization and simulation

In its work characterising and simulating adhesive bonding processes, IFAM acquires a fundamental knowledge of the behaviour of materials and adhesives during bonding processes. This knowledge is used to further improve the adhesion of a material to a surface. The applied, goal-orientated nature of the research means that these activities are contributing to opening up the large potential of modern bonding technology.

In order to determine how an adhesive behaves on particular surfaces, the adhesive-component interfaces are studied by appropriate means – for example by chemical and physical analysis or under the microscope. In addition, computer-aided simulation is applied to model possible configurations of the adhesive molecules with respect to each other and their adsorption and enrichment at the surface. This is then checked by macrokinetic reaction models and the experimental ones, the model assumptions can be verified.

Training and follow-up training

All the IFAM’s knowledge is incorporated in its programme of training and follow-up training: In order to pass on its know-how on industrial application and utilisation directly to technical personnel, IFAM offers high-quality, certified training courses. This allows specialists of all levels to effectively introduce adhesive bonding technology into their production processes to meet their particular requirements. Since 1994, IFAM has trained about 2 100 employees from trade and industry into adhesive engineers, adhesive specialists and adhesive bonders. Practical training can also be held at the institute.
Further information is available on the business fields:

– Adhesive Bonding Technology
– Surfaces.

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