The name »Advanc\c{e}r« conveys a sense of foresight, progress and benefit. Ceramics manufacturers and users find in it their »Advanced Ceramics« materials holding great promise for the future. »Advanc\c{e}r« presents innovative applications for high-performance ceramics: systems solutions with »Ceramics inside« for today and tomorrow.

**Demonstrator**

The demonstration system »CerLag« represents a ceramic piston pin for internal combustion engines. It demonstrates that advanced ceramics are well suited as light-weight and high-temperature materials for components that are subjected to high – partly combined – mechanical and thermal loads. As a piston pin is a primary component the failure of which has serious consequences, life tests are very important to determine its strength and tribological properties.

On the basis of a piston pin for truck engines »CerLag« shows how ceramic components can be designed for high operating loads. The piston pin geometry is initially adopted from a standard component. Silicon nitride was selected as material as it has favorable mechanical, thermal and tribological properties as compared to other ceramic materials. In order to evaluate the fatigue strength in the critical regions of the piston pin, the local operation loads are compared to the local supportable operation loads which were determined for the defined life time. On the basis of a data scattering and a Gaussian distribution the required safety factors for a defined failure probability can be calculated.

In order to get the best results as possible different material combinations (pin-disc design) are tested for their tribological suitability at 120 °C under fluid and mixed lubrication. It is expected that the mass and energy loss can be reduced significantly under mixed lubrication in particular due to the reduced friction coefficients.

»CerLag« is one of six projects within the Fraunhofer Demonstration Center »Advanc\c{e}r« (system solutions with advanced ceramics) that have already been completed.
Survey
Debinding strategies for ceramics

Ceramic green bodies contain a certain amount of organic additives such as binders, plasticizers or deflocculants. The amount of these organic additives which are called for short binders depends on the shaping process. The processes of cold isostatic or uniaxial pressing, for example, require only small amounts of binders (< 2.5 %). In order to manufacture larger and complex-shaped components, shaping processes such as tape casting and injection molding are increasingly used, which require a high organic content. Before sintering the binder has to be completely removed without damaging the microstructure.

Thermal debinding
Thermal debinding is the most used method for binder removal. In this process organic molecules are thermally decomposed and evaporated. If the binder is removed at air, hydrocarbon is also burnt. The evolved gases flow through the pore channels to the surface of the green body. Due to the flow resistance in the pore channels an overpressure develops which can result in crack formation and fracture (Fig. 1).

But on the other hand, a slow debinding process is uneconomical. Thus, the process has to be optimized finding the fastest debinding cycle which can reliably be performed without damaging the green body. Special challenges are large green parts, green parts with high organic content as well as non-oxide ceramics. In the first case, pressure and temperature differences are extremely high due to the long diffusion paths. In the second case, the flow resistance inside the pore channels is particularly high as the channels are clogged with the binder. Non-oxide ceramics are commonly debinded in oxygen-free atmosphere so that elemental carbon can remain in the ceramics which has a negative effect on the sintering behavior and the properties of the final product.

Optimization of debinding cycles
The debinding process is characterized by a complex interplay of chemical reactions and diffusion processes in binder and pore channels. Furthermore, capillary forces result in the redistribution of the binder and depend on the viscosity of the binder and its wetting properties. For practice, optimization strategies have to be developed which can be used with reasonable efforts without trying to understand all phenomena in detail. An universal strategy for optimizing debinding cycles was developed at Fraunhofer ISC in Würzburg, for example, within the framework of several joint projects and experiments with oxide and non-oxide ceramics.

Here, the maximum reliable debinding rate is experimentally determined. For this purpose, the green bodies are rapidly heated up until the green bodies are damaged. The atmosphere of the used laboratory furnaces is adjusted to the atmosphere in production furnaces. The time when damage occurs is noticed from discontinuous changes of in-situ parameters which are collected during the debinding process, e.g. sudden dimensional or mass changes. The corresponding debinding rate is obtained from the mass change rate. For this purpose, the mass of the green bodies is continuously measured by means of a special weight sensor. The debinding rate where just no damage occurs is used as maximum reliable rate for the whole debinding process.

Calculation of the temperature-time cycle
For determining the corresponding temperature-time cycle a computer-assisted calculation is used. The mass changes which were measured for the green bodies at different heating rates are the basis for calculations. The mass change rates are plotted logarithmically in an Arrhenius diagram against the inverse temperature (Fig. 2). All dots on the different curves which belong to the same degree of debinding are joined. In this way so called isolines are created which are used for the simulation of the debinding process at any temperature-time cycle. For this method it is not necessary to know the single processes. Debinding times can be reduced significantly, commonly by 30 to 50 % (Fig. 3). With some ceramics the maximum reliable debinding rate has to be adjusted during the debinding process, e.g. if flow resistance or strength significantly change. Additionally, temperature gradients and wetting phenomena can play an important role. In order to modify the described method additional in-situ measuring methods for thermal diffusivity, flow resistance and mechanical properties are available.

Fig. 1: Mixed oxide ceramic components after fast (left) and correct (right) debinding process (Source: Kennametal)

The Fraunhofer Demonstration Center »AdvanCer« offers various possibilities for technological developments on the basis of comprehensive process and state characterization. At Fraunhofer IKTS for example, the DKG seminar »Debinding of ceramic bodies« takes place on October 23 and 24, 2008. It is the aim of the seminar to explain various debinding methods and to introduce the used equipment. With the help of samples debinding defects are shown and solutions discussed.
News

Energy efficiency in production processes

The efficient use of resources is a task that affects the whole of society and which is focused by industry, research and politics. What can producing companies do to reduce costs and emissions as well as to protect resources by more efficient technologies? Within the framework of the study »Research for tomorrow's production« funded by the German Federal Ministry of Education and Research (BMBF) eight Fraunhofer institutes and other research institutions analyzed the potential for producing companies to save resources and energy, in particular. Knowing the potential the scientists derived the need for action for the branch of production research. In addition to potentials in the production and systems integration of advanced ceramics (optimization of debinding and sintering processes, heat recovery and coupling, miniaturization, as well as co-shaping and co-firing strategies for multifunctional materials) the application of ceramic components particularly provides various possibilities to make production processes more efficient (e.g. cutting performance). Furthermore, significant energy savings can be realized over the whole life cycle by using specific functional properties of advanced ceramic materials in the total system.

European Culture Award for Meissen Porcelain Manufactory

At the end of March the Meissen Porcelain Manufactory (Staatliche Porzellan-Manufaktur Meissen) received the European Culture Award 2008. The price has been awarded since 1993 for achievements which are positive and essential for Europe's future, but which have not been completed. The jury explained their decision, saying on the basis of the first recipe of the European porcelain in 1708 the Meissen manufactory had established the European porcelain industry. The invention did not only change the European table ware and manners, but it also has influence on today's arts and crafts as well as ceramic technology. The award was presented by Stanislaw Tillich, then Saxon finance minister and today's prime minister, Dieter Topp, president of the KulturForum Europe (KFE) e.V., and retired general Walter Jertz, prizewinner in 2006. Dr. Hannes Walter, managing director of Staatliche Porzellan-Manufaktur Meissen, accepted the award: »It is a great pleasure for us that the achievements of many manufacturer generations for the European porcelain culture are appreciated. As the manufactory is the first producing company receiving this price, its double function as business and cultural institution is emphasized.«

E3 Material Award for ETEC

At this year's Hannover Messe the newly developed compact tube bend of ETEC company was awarded the E3 material award. Significant criteria for the jury to award a product with the E3 material award are innovation, creativity, engineering stage and its potential for development. For the first time, ETEC's compact tube bend allows for installing advanced ceramic wear protection liners even into piping systems with extremely narrow bends, and in this way, radiusses with less than 500 mm can be realized. Thus, the service life of tube systems can be increased and significant energy savings achieved. Already in 2007, ETEC was honored with the E3 material award for its ceramic track system for ski-jumping hills. E3 has become internationally renowned by means of the »E3 design award« which has been organized since 1954 on a yearly basis. It is considered to be one of the most important design competitions worldwide. Furthermore, ETEC's compact tube bend was nominated for the Design Award 2009 by the German Federal Ministry of Economics and Technology (BMWi). This design award is given for excellent performances in the field of industrial design of series products as well as communication design.

Long Night of Sciences in Dresden

On July 4, 2008 the Fraunhofer Institute Center Dresden invited interested people who were curious and hungry for knowledge to explore the exciting research world of Fraunhofer for one night. In laboratories and pilot plants they could experience and feel technology. Children, pupils, trainees and students, in particular, were warmly welcome.

Current Training Courses

»AdvanCer« continuous its training courses »Advanced Ceramic Materials for Technicians and Engineers«. The three training parts on offer are meant to be taken consecutively, but they can also be taken individually. Dates and locations are as follows:

- Part 3: Construction, materials testing, quality assurance and application behavior. November 13 and 14, 2008 in Freiburg
- Part 1: Introduction into ceramics: manufacturing technologies, properties, applications. March 11 and 12, 2009 in Dresden

For further information please see www.advancer.fraunhofer.de

Furthermore, the following advanced training courses of the German Ceramic Society (DKG) will take place at Fraunhofer IKTS in Dresden:

- September 10 to 12, 2008: »Spray drying of ceramic suspensions – Technology and statistical test planning«
- October 8 and 9, 2008: »Thermoplastic shaping of advanced ceramics – Technology and training«
- October 23 and 24, 2008: »Debinding of ceramic bodies«

For further information please see www.dkg.de
Kerafol Keramische Folien GmbH is a world-wide specialist in ceramic tape development and manufacture. State-of-the-art production plants and clean room technology are available on a company site of 50,000 m². Kerafol produces oxide and non-oxide tapes with thicknesses ranging from 20 µm to 3 mm and a width of up to 1 m. Founded in the mid 1980’s the company has grown to over 200 employees. Besides its founder Franz Koppe his daughter Isabell Koppe is also represented since two years in the company’s management.

In addition to the business sectors of SOFC Products (energy technology), Thermal Management (microelectronics) and Kiln Furniture the sector of Ceramic Membranes (environmental technology) becomes more and more important. Ceramic discs for microfiltration and ultrafiltration are used in rotation filtration plants (dynamic cross-flow filtration). They provide best thermal and mechanical stability, and thus, ensure long service life. Furthermore, they can be cleaned by back-flushing and hot steam sterilization. In the ceramic industry these systems have already proved to be suitable for the microfiltration of glaze suspensions. Here, not only the glaze can be recycled by concentrating the solids content to 60-70 wt %, but the clear filtrate can also be used again. Thus, high water and wastewater costs can be saved and expensive glazes can be recycled. Rotation filtration can also be used in many other industry sectors (food, paper, chemical or metal-working industry, etc.).

Ceramic injection molding: Tough components in complex geometries

By using three dimensional advanced ceramic injection-molded (CIM) parts product planners as well as design and development engineers are able to realize complex designs and diverse applications. CIM parts are high quality products and often provide cost advantages over conventional material solutions and production methods. Kläger Spritzguss supports its customers in engineering, mold making and introducing a reliable series production. The company takes responsibility for the whole project.

Kläger’s in-house material development ensures high process stability and provides the necessary flexibility in research, development and testing of new moldable ceramics. In addition to alumina, zirconia and mixed ceramics Kläger also produces CIM parts of electrically conductive TiO₂ which can be applied e.g. as electrodes in humidifiers. In close collaboration with Fraunhofer IKTS a stable feedstock was developed and verified on the basis of a sintering process under reducing atmosphere which allows to adjust the electrical conductivity within a defined range.

»Advanced Materials Inside«: As enterprise providing its customers full service Kläger is also able to integrate ceramic products into complex assemblies, e.g. in plastic injection-molded parts. The extensive know-how of Kläger fully pays off in the production of plastic, ceramic and metal composites.