The name »AdvanCer« 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. »AdvanCer« presents innovative applications for high-performance ceramics: systems solutions with »Ceramics inside« for today and tomorrow.

Demonstrator »C-SiC«

Fiber-reinforced ceramic composite materials for brake and clutch disks are on the upswing. On the one hand, these light materials have a unique potential, e.g. in applications subject to high thermal and tribological stress. On the other hand, they pose the challenge of a complex manufacturing process including final machining. In order to develop cost-efficient and quality-optimized machining technologies for fiber-reinforced ceramics, samples from carbon-fiber reinforced silicon carbide (C-SiC) were machined and analyzed in terms of surface quality and boundary layer in the Fraunhofer Demonstration Center »AdvanCer«. The C-SiC samples are made from the same material as the ceramic composite clutch disk of the Porsche Carrera GT (PCCC) and machined using innovative grinding methods. After the samples were machined by high speed and high performance surface grinding with planetary kinematics, they showed excellent smoothness and surface quality. Moreover, the processing time could be reduced by a factor of 5 as compared to conventional machining methods. The method of speedstroke grinding has high potential as well. In the first studies an increased productivity and reduced damage of the samples could be proved as compared to conventional reciprocating grinding.

»C-SiC« is one of another five demonstration systems which are developed within the framework of the Fraunhofer Demonstration Center »AdvanCer« (system solutions with advanced ceramics).

Fine machining by means of surface grinding with planetary kinematics.
Survey

Particle-based simulation methods

The development of new, particle-based simulation methods supports the continuous improvement of various ceramic manufacturing methods. Models adjusted to the respective problem allow one to describe the transport of dry powders or the flow of complex ceramic slurries and pastes.

Basics

In addition to continuum mechanical simulation approaches based on finite elements, which are already widely spread in ceramic industry, different particle-based simulation methods have recently been developed which are well suited to investigate and optimize ceramic manufacturing methods. On account of the powder’s granular nature the discrete element method (DEM) is suited. In this case, the medium to be simulated is described in form of single, discrete particles. All particles flow according to the Newtonian laws, and the forces between the particles and the liquid medium are formulated according to the process to be modeled.

Dry compaction

Dry compaction followed by sintering to shape ceramic powders is characterized by a high dimensional accuracy. A homogeneous filling process of the die before pressing is an important prerequisite in order to realize geometric accuracy as density gradients cannot be completely compensated during pressing and may lead to warpage. Mostly, a feed shoe is used for filling. It passes the cavity once or twice and discharges the powder (Fig. 1). The feed shoe’s kinematics, amongst others, can be adjusted to optimize the filling process in terms of a best homogeneous density distribution. It is the aim to better understand and optimize this process with the help of simulations in order to avoid complex and time-consuming trial and error studies.

Using the DEM it is possible to show global rearrangements within the bulk material and to reflect the particle shape (Fig. 1). The flow behavior is monitored by model parameters which are determined by experiments for a given powder. The heap angle of a free-flowing powder, for example, depends on the particle shape and the interparticle friction. The Fraunhofer IWM in Freiburg uses this adjusted model to simulate filling processes for any die the customer likes. Figure 2 shows simulated density distributions after the filling process for two simple dies. It can be observed that low filling speeds result in higher densities. Furthermore, the powder is more compacted in direction of the last shoe passage which describes the influence of the die geometry as well. The simulations, thus, give information about critical density gradients, and help to adjust the feed shoe’s kinematics.

Tape casting

New simulation methods are also used to optimize tape casting processes in which thin, large-size green tapes are made from ceramic slurries. Simulating the flow in the slurry reservoir conventional methods such as computational fluid dynamics (CFD) have their limits. In this case, the particle-based smoothed particle hydrodynamics (SPH) method is advantageous. The complex slurry rheology depending on the local flow situation can be systematically modeled. The 2D simulation of a typical tape casting process (Fig. 3) shows that there is a backflow between the doctor blades. By means of particle simulation the geometry can be optimized step by step. It is also possible to give information on the microstructure of the tapes by linking microscopic DEM simulation of representative areas. Thus, predictions can be made about the flow situation’s influence on the arrangement of the ceramic particles.

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News

Ceramics Meeting Point – TASK GmbH

In 1989 the TASK GmbH (Technology Agency for Structural Ceramics) was founded celebrating it’s 20th anniversary this year. In the meantime TASK GmbH has become a well-established agency, which – according to the original philosophy – provides a network of manufacturers, suppliers, users of ceramics and research institutions. Members and visitors appreciate »Ceramics Meeting Point« as permanent exhibition in Dresden or as booth at the Hannover Messe. It is an important drop-in center where market information is given, contacts are made and projects are initiated. Having an exhibition area of 300 m² at Hannover Messe and 400 m² at CERAMITEC, 2009 will be a highlight for public relations. Within the framework of the »Day of Technical Ceramics and Powder Metallurgy« on October 21, 2009 advanced ceramics are presented in their full spectrum at this year’s CERAMITEC: from raw materials to systems and from wear protection to sensor applications. At the booth of TASK 39 partners present their innovations from and for ceramic industry.

HITK becomes branch of Fraunhofer IKTS

The Hermsdorf Institute for Technical Ceramics (HITK) will be integrated into the Fraunhofer-Gesellschaft in 2010 and become a branch of the Fraunhofer IKTS. Already in May this year the Thuringian government agreed to fund the integration process for five years and to co-finance the construction of a new institute building. Furthermore, it promised to support the establishment of a professorship at the Friedrich-Schiller-University in Jena.

The HITK was founded in the end of 1992, and has been growing from 47 to 120 employees, one third of which works in the subsidiary Inocermic. In 2008, the total budget amounted to 10 million euros. Its profile focusing on membrane technology and high-purity oxide ceramic components will be continuously consolidated and improved so that present and new customers can be offered established and further developed products and services. By merging both institutes the material and process related as well as application-specific competencies of HITK and IKTS complement one another resulting in a unique range of products and services for a comprehensive and competent contract research in all fields of advanced ceramics, particularly focusing on environmental and energy technology. Research and development can be offered through the entire value chain from the material to the system in complete production lines up to pilot-plant scale. In this way, the access to innovative solutions is made easier, and technology transfer is significantly accelerated. The colloquium »Ceramics Vision 2010« will take place for the first time in Hermsdorf on January 22, 2010, celebrating the merger of both institutes.

Industrial seminar »Spray drying«

On September 7 and 8, 2009 an industrial seminar on »Spray drying in powder technology« took place at Fraunhofer IKTS, which was attended by more than 80 participants from industry and research institutions. The attractive lecture program was completed by interesting tours through pilot plants, laboratories and presentation rooms. Within the framework of the seminar Dr. Manfred Nebelung, head of the »Powder Technology« working group at IKTS and leader of the competence center »Powder Technology«, was honored and bid farewell on his retirement.

Autumn symposium of the German Ceramic Society

On December 1 and 2, 2009 the traditional autumn symposium of the German Ceramic Society takes places in Erlangen. Under the headline »Plastic and thermoplastic shaping« the symposium focuses on the ceramic manufacturing methods of extrusion and injection molding with practically oriented presentations and an accompanying exhibition.

For further information please see www.dkg.de

Current »AdvancCer« training courses

- Part 3: Construction, quality assurance and application. November 12 and 13, 2009 in Freiburg
- Part 1: Introduction into ceramics: manufacturing technologies, properties, applications. March 10 and 11, 2010 in Dresden
- Part 2: Machining of advanced ceramics. May 5 and 6, 2010 in Dresden or Berlin

For further information please see www.advancer.fraunhofer.de
Ignition element for pellet radiators.

Success Stories

New ceramic high-temperature heating elements and hot surface igniters

Heating elements for temperatures of more than 900 °C, which are suited for heating and ignition processes, have been made from specific and expensive Sr3N4, MoSi2 or SiC materials so far. In the past years, the Rauschert Steinbach GmbH has developed new heating elements based on Al2O3 in collaboration with the Georg-Simon-Ohm University of Applied Sciences Nuremberg. These so-called hybrid heating elements contain metal conductors, and are either rotationally symmetric (tubular, rod-shaped) or flat. The conductors are applied on the Al2O3 body by screen printing and covered with a protective layer so that the conductors are electrically insulated and completely hidden inside the component. The manufacturing technology is very flexible so that small series production is also efficient. Such heating elements are applied as hot surface igniters for wood pellets and chips. In this process, the ceramic component is heated up to 1000 to 1200 °C, whereby the pellets ignite very fast. The patented igniters require only 1/10 of the energy conventional heat guns need.

Further applications are: tool heating elements, miniature kilns or reactors e.g. for chemical industry as well as heat guns for highest process temperatures. The new heating elements may be advantageously used for melting, welding, evaporating or brazing processes as well, whereby the efficiency of machines and automates can be increased. Rauschert, thus, offers a unique range of products in the field of heating and ignition: from PTC and high-temperature heating elements and hot surface igniters, through heating conductor substrates and MgO ceramics for cartridge heaters up to ignition electrodes for gas ignition.

PTC heating elements in glue guns

In collaboration with the STEINEL company, EPCOS developed a new, custom-fit (»formfit«) ceramic heating element: On the basis of this »formfit« heating element a glue gun was developed and introduced into the market having the shortest warm-up time worldwide. »The collaboration with STEINEL resulted in the first serial application of our »formfit« heating elements«, says Dr. Jan Ihle, who is responsible for process development of PTC resistors. »Our innovative components, which we are able to produce in many different geometries now, can be applied in many different fields – ranging from systems for preheating of alternative fuels in vehicles up to electrical household appliances such as coffee makers.«

By means of the new injection molding technology of EPCOS ceramic heating elements can be produced like plastic components, e.g. as tubes, nozzles or rotor blades. So far, only simple geometries such as disks, rings, and quadrangular plates could be produced. The developers of STEINEL, producing glue guns for more than 30 years, were also convinced of the advantages of this shaping technique. In collaboration with EPCOS in Deutschlandsberg the first »formfit« heating element was developed which is housed in the head of the new glue gun. As compared to conventional glue guns, the heating element was directly placed in the outlet nozzle, and thus, supplies heat exactly at the glue stick. As there are hardly thermal losses, the glue gun has the shortest warm-up time worldwide. Another advantage for workmen and handicraft workers: Due to the low thermal losses the glue gun can be operated with a storage battery resulting in more flexibility.