CERAMIC-COMPATIBLE DESIGN OF COMPONENTS

Due to the latest developments in the field of materials and components simulation it became possible to evaluate and optimize complex components in terms of their application behavior. So far, it has been difficult to calculate the risks.

It is possible to use ceramic materials for components which are subject to tribological stress such as milling tools, gear wheels, extrusion tools and ceramic screws (figure on the right). Here, new application fields for advanced ceramics can be opened if the reliability and the operational safety are sufficiently high. In order to simulate such components and to precisely evaluate their application behavior it is necessary to gain knowledge about the material properties and their possible change during the manufacturing process and in operation.

For this purpose, the experimental methods for the characterization of local stress and load-bearing capacity were improved in that way that residual stress and load-induced stress as well as phase contents were determined at a resolution of 5 μm. These methods – combined with a continuous detection of the wear rate in laboratory tests – allow to evaluate the application behavior of ceramic components subject to mechanical and tribological stress.

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Ceramic drive gears

For ceramic drive gears, it is important that the torque transmission is constant and that the teeth engage smoothly. Within the framework of a joint project funded by the Federal Ministry of Economics and Labour (BMWi), Fraunhofer IWM, FCT Hartbearbeitungs GmbH and the University of Applied Sciences of Zwickau manufactured and evaluated geometries which had been optimized by finite element simulation before. For SSiC ceramics, the expected tensile stress in the critical areas, particularly at the tooth root, was reduced so far that a tooth root strength which is high enough for torque transmission was achieved after final machining.

In addition to the bending stress at the teeth, their wear has also to be considered as wear at the tooth flanks leads to geometrical changes which again effect the whole stress situation. At ceramic drive gears, wear occurs in rolling contact between the tooth roots. The resulting contact pressures and glide paths are the most important influential factors.

Using tribological model tests such as rolling contact fatigue tests it is possible to determine wear in dependence of contact-mechanical stress. The effect of contact pressure and slip is implemented into the simulation by means of wear principles. Moreover, such tests can be used to determine critical mechanical loads, above which critical contact damage such as pits and cracks may develop. Due to the high corrosion resistance of SSiC in aqueous media, this material was chosen for drive gears in a fluid-lubricated multiphase pump of Bornemann Pumps GmbH. The drive gears produced by FCT Hartbearbeitungs GmbH are currently tested at Bornemann.

Ceramic screw threads

Ceramic screw threads put high demands on the design process. The unfavorable notch effect of the thread and the high friction coefficients are much more critical for ceramic materials than for steel. When the thread is screwed by torsion, high friction coefficients cause high stress which is similar to that generated by tensile stress. In contrast to steel, a coarse thread achieves a higher preload with the same torque as compared to a fine thread. The interaction of expansion constraint and torsion is calculated by finite element simulation using thread simulations. For designing the thread root of the screw that is more stressed it did not prove to be advantageous to shape the notch radius but to reduce the notch in a specific trapezoid shape. In order to cover the aspects of manufacturing and machining, this project – funded by the AiF – is carried out in cooperation with Fraunhofer IKTS and the IWF of TU Berlin.

Ceramic milling cutter

Within the framework of an INNONET project in cooperation with industry partners, Fraunhofer IPK, IWF of TU Berlin as well as IfWW of TU Dresden, state-of-the-art multiple, peripheral and roughing cutters made from SiAlON ceramics were developed for the milling of materials which are difficult to machine. They allow for an 8 times higher removal rate as compared to hardmetal cutters. In this collaboration, the focus of Fraunhofer IWM is on the evaluation of the contact stress and the reduction of the degradation of the cutting edge. The suitable geometry allows for homogeneous power transmission from edge to edge through as many edges as possible and adjusted helix angle and groove depth.

Prospects

Degradation processes have a negative effect on the reliability of ceramic components. In order to describe these processes, it is the objective of an EU project (www.rolicer.eu) to combine finite element simulation with atomistic and mesoscale simulation as well as the methods of fracture mechanics.
SUCCESS STORIES

PRECISE AND DENSE CERAMIC COMPONENTS BY ADDITIVE MANUFACTURING

Additive manufacturing technologies have already been established in plastic and metal processing industries as an effective supplement to conventional manufacturing methods. However, in today’s ceramic industry, this technology has hardly been established as the obtained material qualities have not met the high requirements so far. In particular density and strength were not sufficiently high to match the results of conventionally produced ceramic parts.

Now, Lithoz GmbH provides an additive manufacturing technique by means of which it is possible to produce ceramic components of a very similar quality with the same material properties as obtained by conventional methods. This method is called Lithography-based Ceramic Manufacturing (LCM) and it is a slurry-based process which was developed at Vienna University of Technology. The slurry comprises a photosensitive resin and the homogeneously dispersed ceramic particles.

Upon irradiation the initially liquid slurry is solidified and cured in a layer-by-layer manner to build up the desired object. Using the LCM-based CeraFab 7500 system which was developed and brought to the market by Lithoz, densities higher than 3.96 g/cm³ (99.4 % of the theoretical density) and a 4-point bending strength of 430 MPa with a Weibull modulus of 11 can be obtained for the standard material Lithalox HP 500, a slurry based on a high-purity alumina powder.

Due to these excellent mechanical properties, the produced parts can be used without any limitations. The LCM technology not only allows the cost-effective production of prototypes and small series within a very short time, it is also suited to manufacture highly complex geometries that cannot be realized by conventional manufacturing methods.

Lithoz has six employees with various technological backgrounds covering the entire process chain from the CAD files to the sintered ceramic components.

ALL-CERAMIC CUTTING TOOLS FOR MILLING OF PLASTICS

Hufschmied Zerspanungssysteme GmbH from Bobingen has acquired a leading position in the cutting of new, non-metal materials. As it early concentrated on the cutting of plastics, glass fiber materials and carbon fibers, the company has more than 25 years of experience in this field. Hufschmied is a specialist supplier who consistently traces the further development of new materials and provides cutting tools for their machining. The product portfolio includes high-performance tools for mold and tool making as well as a broad product range of specialty tools for the machining of plastics.

Managing director Ralph R. Hufschmied says: “We do not consider ourselves as product seller, but as partner who accompanies its customers from the pre-production series to the finished product with excellent process consultancy.” Hufschmied specialty tools are applied in all branches which process new materials in series production. Leading manufacturers in the automotive industry, aerospace industry and med-tec rely on the know-how from Bobingen.

The new all-ceramic cutting tools based on zirconia are the latest example of the company’s effort to further develop its products consistently. The cutting tools are optimized for high-speed cutting of plastics. The ceramic material is extremely light. The tools achieve high speeds without stressing the spindle bearings. The new chip geometry allows for very high feed rates. For easily fixed workpieces, very good results can be obtained by maximum speeds and high feed rates per tooth. The ceramic material does not heat up even in such extreme cutting processes. The resulting heat is completely dissipated through the chip avoiding smearing of the material reliably.
IMPORTANT DATES

AdvanCer training courses “Advanced ceramic materials”
- Part 2: Machining
  May 14 and 15, 2013 (Berlin)
- Part 3: Construction, testing
  November 7 and 8, 2013 (Freiburg)
- Part 1: Materials, technologies
  March 5 and 6, 2014 (Dresden)

Seminars and workshops at Fraunhofer IKTS
- Workshop: Nano- and membrane-based systems for water treatment
  April 17 and 18, 2013
- Symposium: Thermoelectrics – From materials to systems
  April 17 and 18, 2013
- ISPA 2013 – International Symposium on Piezocomposite Applications
  September 19 and 20, 2013

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

NEWS

NEW PUBLICATION FOR ADVANCED CERAMIC COMPONENTS

The Göller Verlag from Baden-Baden will be publish the new technical journal “Ceramic Applications” from March 2013 which will report on ceramic components, their manufacturing technologies and applications twice a year. With a circulation of 11,000 copies and an online issue the publishing house wants to create an international platform for technical and market-relevant information regarding the topics design and application of ceramic components in various industrial sectors.

Each issue has a central topic and is supplemented by best-practice stories, user feedbacks, market and fair reviews, technology insights and supplier profiles, as well as news items on companies, people, products and events. The first issue informs about economic and sustainable products in the field of energy and environmental technology. “Ceramic Applications” addresses all innovative engineers and natural scientists in product design and development, as well as product management, purchasing and marketing.

The editorial team is supported by a network of industrial associations and institutes focusing on applied R&D in ceramic materials science and process engineering.

INNOMATERIA – EXPERTS MEETING OF THE INNOVATIVE MATERIALS SECTOR

InnoMateria, the international fair for the furniture and interior construction industries’ supplying sections, will take place for the third time in Cologne from May 14 to 15, 2013. With the new topic “Interior and Design”, InnoMateria supplements its established topics lightweight construction, mobility and energy. By combining the three components of congress, trade fair and call for projects into one cohesive event, InnoMateria has become the established interdisciplinary communication platform for innovative materials, where all the stakeholders from materials research to materials engineering and application come together to engage in a multidisciplinary exchange of ideas.

Under the headline “Interior and design with ceramic parts as key components” Fraunhofer AdvanCer participates in the innovation forum. Here, the Alliance presents advanced ceramics in new, unexpected applications in the field of designer mobiles, automobile engineering, lighting technology or functionalized furniture. Structural ceramics with their special haptic effect as well as functional ceramics for intelligent furniture are introduced. In the context of scientific discussion and application, latest developments ranging from transparent ceramics to industrial-scale injection molding techniques are presented in the innovation forum.

EDITORIAL NOTES

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